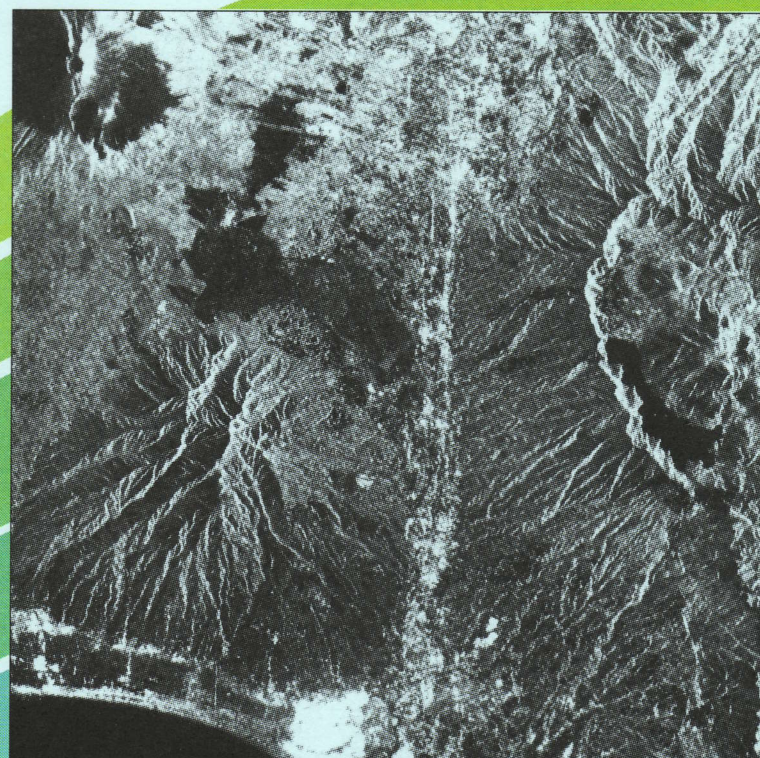
# The FUTURE of the GLOBAL ENVIRONMENT:
# The Role of Canadian and Japanese Science and Technology

***Proceedings of a Symposium***



**October 19, 1993**
**The Chateau Laurier Hotel**
**Ottawa, Ontario, Canada**

**Co-sponsored by**

**THE HONDA FOUNDATION**

**THE CANADIAN GLOBAL CHANGE PROGRAM**

**THE INSTITUTE FOR SPACE AND TERRESTRIAL SCIENCE**

**AND ATMOSPHERIC ENVIRONMENT SERVICE, ENVIRONMENT CANADA**

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*No. IR94-2*

*THE ROYAL SOCIETY OF CANADA*
*June 1994*

# *The* FUTURE *of the* GLOBAL ENVIRONMENT:
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*Cover photograph:* *The Mount Fuji and Hakone National Park area in Japan taken by the JERS-1 satellite. Courtesy of the National Aerospace Development Agency of Japan.*

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# Preface

These proceedings are the product of an exciting symposium on the role of Canadian and Japanese science and technology in the future of the global environment, held on October 19, 1993 in Ottawa, Canada. The symposium was the result of ever-increasing concern in both Japan and Canada about environmental problems, and awareness that the solutions to those problems must transcend national boundaries if they are to be effective.

Senior Japanese and Canadian decision-makers from the science and technology sectors of government, industry and universities participated in the symposium. They were all interested in discovering how Japan and Canada could collaborate in scientific research and technological development to improve the state of the global environment. The specific objectives of the symposium were to identify the human and physical issues of environmental change that could benefit from Japanese-Canadian collaboration, and to explore the roles of science and technology in addressing these challenges over the next five, ten and fifteen years. These goals were achieved through a series of presentations followed by discussion sessions. The final objective, addressed through a panel discussion at the end of the day, was to try to identify priority areas where collaboration might successfully occur in the future.

The most important outcome of the symposium was the awareness that was raised among Japanese and Canadian decision-makers of a mutual interest in research and technological innovation that will mitigate global environmental problems. It is the fervent hope of the organizers of this symposium that their shared interests in environmental research and technology will translate into fruitful partnerships that will contribute to the solution of a broad range of environmental problems facing Japan, Canada and the rest of the world.

*Brian Bornhold*
*Director*
*Canadian Global Change Program*

## Co-Conveners:

Dr. Brian D Bornhold
Director, Canadian Global Change Program, The Royal Society of Canada

Dr. Joji Iisaka
Senior Research Scientist, Canada Centre for Remote Sensing, Natural Resources Canada

Dr. Ellsworth LeDrew
Professor of Geography, University of Waterloo and Director for Environmental Change, Institute for Space and Terrestrial Science

## Symposium Officers:

Marie Ross, The Royal Society of Canada

Michiko Iisaka, Symposium Liason, General Officer

# The Honda Foundation

Modern society has achieved greater prosperity than ever, thanks to sustained high economic growth which has been made possible through a rush of technological innovations in production, transportation, communications and other activities. We are experiencing revolutionary changes in our way of life, and in our changing life-style we have also expanded our horizons.

This achievement, made at a fast pace, has had negative effects too: environmental destruction, pollution, urban density, population explosion, food shortages, growing nationalism plus a number of other deep-rooted, complex issues.

Serious efforts have been made to resolve these problems. Each of them, however, is a kaleidoscopic reflection of different elements of modern civilization, and thus requires a completely new approach in the search for a resolution.

A makeshift resolution serves no purpose. Wisdom and effort must be pooled on an international level, and through an interdisciplinary approach to the analysis of modern civilization, the results can be used for the promotion of human welfare and happiness. In such a way must we strive to create a higher level of human society.

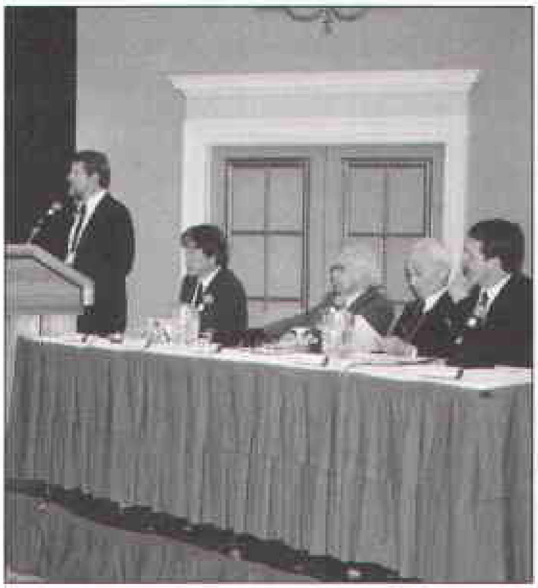
In order to provide the opportunity for scholars, researchers and specialists from all walks of life, irrespective of nationality, to meet together and freely discuss the present state and the future of our civilization, the Honda Foundation sponsors international exchanges, symposia and study groups, and offers prizes and awards for the promotion of research, education and other such activities, and also carries on its own study and research, making use of the achievements of modern civilization. The Foundation was established with such objectives in mind, and by extending its own activities to fulfil the requirements of the modern age, it contributes towards the creation of a truly humane civilization.

# The Canadian Global Change Program

The Canadian Global Change Program (CGCP) is the national focus for global change information, education and research activity in Canada. Its activities are closely linked to those of The Royal Society of Canada, which established the CGCP in 1985. The CGCP is a conduit to other national and international efforts, including the World Climate Research Program (through the Canadian Climate Program), the International Geosphere-Biosphere Programme, and the International Human Dimensions Programme.

Core funding for the CGCP is provided by the federal government through Environment Canada's Green Plan. Additional funds and other support are provided by the Richard Ivey Foundation, federal research agencies, provincial governments and agencies, the private sector and non-governmental organizations.

# The Institute for Space and Terrestrial Science



The Symposium was sponsored in part by the Environmental Change theme of the Institute for Space and Terrestrial Science (ISTS).

*The mission of the Institute for Space and Terrestrial Science is:*

- to achieve and maintain world leadership in multidisciplinary collaborative research in space and terrestrial science, and engineering;
- to transfer and diffuse the products of that research to ensure the future global competitiveness of our home-based industry;
- to contribute to the education and training of future generations of scientists, engineers and technologists;
- to raise public awareness of the value of space and terrestrial science to society.

*ISTS Vision Statement:*

This Ontario Centre of Excellence provides leadership in key areas of multidisciplinary space and terrestrial science, engineering and education, to stimulate collaborative research and industrial development.

# Opening Remarks

*Dr. John Meisel*
*President, The Royal Society of Canada*

Ladies and gentlemen, friends, it is my very great pleasure to welcome everyone to this symposium convened to explore the roles of Japanese and Canadian science and technology with respect to the future of the Global Environment. We confront today a large and important task. First, I think, it is large because of the relevance to human well being of the future of the environment. And it is important also because this is a relatively rare Japanese, Canadian collaboration. The Royal Society of Canada is very keen indeed to develop further ties and cooperative projects between Japanese and Canadian colleagues, projects which we think would be mutually enriching to both groups of participants. Before I go any further, I would like to discharge a pleasant duty. I would like to express my warm appreciation to several organizations for generous support which they have provided for our symposium today. In the first place, there is the Honda Foundation and particularly its president, Mr. Hiromori Kawashima. Without his help this event would probably not have occurred.

Secondly, I would to acknowledge the assistance of the Institute for Space and Terrestrial Science through Dr. Ellsworth LeDrew of the University of Waterloo, and also acknowledge with pleasure the help of Atmospheric Environment Service of Environment Canada, through Dr. John Reid. These efforts made it possible that we could meet here today. The Royal Society of Canada has promoted scholarship in this country and elsewhere for well over a century by conducting inquiries, holding symposia, publishing scientific papers and generally encouraging the pursuit of what we like to call "matters of the mind" in all fields—not just in science and technology. We have academies of social sciences and humanities, and we have an academy of letters and arts for primarily francophone members. Important among these large scale efforts that we have being pursuing with increasing vigour and energy have been problems and issues emerging from the environment. We have done studies which have been published and received wide reception in such matters as lake acidification, the quality of water in the Great Lakes, lead in the environment, nuclear power safety and many others. In the recent era, these and related concerns have been brought under the umbrella of our largest program, the Canadian Global Change Program, of which Dr. Bornhold is the Director and which has organized this symposium.

The understanding and the search for solutions in the field of environment is a multidisciplinary task. In other words, it cannot only depend on the contributions of science and technology although they are, of course, of critical importance, but they are only part of the picture. The social sciences and humanities are also essential as are questions of ethics and moral issues, and values of society. All of these interact with matters of science and technology to shape the kind of environment in which we live and the kind of environment which we create. I am glad to say that today's agenda very well reflects this broader context in which society issues have to be confronted and I think that is one reason why I expect that today's activities will be an extremely useful experience for all of us. But the cooperation among disciplines is not the only synergy that we expect here. The interaction among countries, regions and cultures is equally essential. This is the reason why in this symposium we can draw both on the Japanese and Canadian participants to strengthen the insights that will be derived from our experiences.

Japan is a major player. It has extremely important technological and scientific capabilities. It has a strong economy. It has developed enviable industry-government cooperation. These are important building blocks upon which to develop strategies suited to cope with current and future environmental issues. Canada too is an advanced nation and of course is the custodian of a significant portion of land and water resources and natural resources in the world. This gives us special responsibilities and also special opportunities to play our part in the task that all of humankind now confront.

This symposium is one of the first attempting to bring together Japanese and Canadian decision-makers in government and industry. Decision-makers of certain seniority. To bring them together to see how the two countries might help one another and the world to confront environmental challenges. This, I hope, is to be a beginning of major joint developments in this area between our two countries.

The Royal Society of Canada attaches enormous importance to the pooling by Japan and Canada of experiences, intellectual resources and insights which we can bring together towards effective policies. Therefore I am very pleased and indeed I am proud that we have been able to cooperate with other sponsors in launching a promising and rewarding joint symposium. On behalf of the Royal Society of Canada I therefore again welcome you and wish you the very best in this pioneering task.

# 1. Human Dimensions of the Global Environment

*Chairman: Dr. Joji Iisaka, Senior Research Scientist, Canada Centre for Remote Sensing*

## The Problem of Human Reproduction

*Kei Takeuchi*
*Professor, Research Centre for Advanced Science and Technology, Faculty of Economics, University of Tokyo*

First let me add a little to the formal introduction of me by the chairman. I am a professor of statistics, long affiliated with the Faculty of Economics of the University of Tokyo. About six years ago, the University of Tokyo established a new research institute called the Research Center for Advanced Science and Technology (RCAST for short) as a joint project by different faculties of the University of Tokyo. I was delegated there from the Faculty of Economics, and took charge of the Department of Correlation between Society and Science and Technology, keeping a joint appointment at the Faculty of Economics. There I organized and directed a research group which has been engaged with the research project sponsored by the Ministry of Education of the Japanese Government titled, "Perspective for Technologically Highly Advanced Society." The research group consists of about two hundred people from different specialties and from various universities. In our research the central issue is how to solve through development and implementation of science and technology the so-called dilemma between the need for social development and economic growth on the one hand and the constraints imposed by finiteness of natural environment and resources on the other. Our main concern is to find a course where these three factors can be harmonized and world society can develop in a desirable manner in the 21st century.

We found that one of the most important, if not the most important, issues in relation to environment and resources is that of supply and consumption of energy. And, in turn, we found the most decisive factor is the size of the world population, to what level and how quickly it grows.

There has been much talk about sustainable growth, but sustainability can be realized only when both its natural aspects and social aspects are harmoniously attained. The most basic factor with regard to social sustainability is population, its size and its distribution. Now it seems to be generally agreed that sometime in the next century the world population will reach at least double the present size, or ten to twelve billion, which automatically means that world production of basic necessities must double within a corresponding time limit. Though we can admit that there is overconsumption and excessive use of goods and resources in many parts of the world, there are still hundreds of millions of people without the minimum necessities for subsistence. It would be safe to assume that economic growth must be at least proportional to population growth.

The most important question as regards the population problem is whether population growth is the result or cause of economic growth. From a Malthusian viewpoint, human population has an intrinsic tendency to grow and could be only checked by the limit of food production. In Ricardian theory of 19th century economics, population and food production will reach equilibrium in the long run. According to such theory, excessive population growth would render lower wages through competition and a low living standard, which in turn would reduce population growth rate, and then the balance between population and natural resources will be recovered. In case of abundance, a higher wage level would render high population growth and excessive population would bring the wage level back down to the normal level.

But both theories are discredited by the historical course of modern society, where higher levels of economic welfare coincide with lower birth rates and a lower population growth rate. And now most economists agree that population growth must be treated as exogenous, that is, determined outside of economic processes. Economics cannot determine the speed of population growth.

But it is also agreed that the birth rate turns downward only when average income approaches a certain level, I don't know exactly the amount, but it is a level substantially higher than the minimum level of subsistence. Thus if we assume that sustainability means stabilization of population size, some economic growth is necessary to attain it.

Here I would like to point out some problems related to population growth, especially that of the birth rate and more generally that of human reproduction. I think that there is a strange contradiction in modern society or the modern concept of society. Logically speaking, any social system can be sustainable only when the population size is kept more or less constant and its membership is replaced by a new generation in an orderly manner. Therefore it should be the first concern of any human society (or even of animal species) to maintain a proper system of reproduction of its members in the face of ecological change, and to keep its size and structure in equilibrium with environmental pressure. The system of human reproduction is the most important feature of any primitive society. But the basic contradiction of modern society is that it has no inherent logic of human reproduction. On the one hand, through technological development in medicine and hygiene, and also by advancement of economic welfare, it pushed down the death rate and reduced the power of ecological pressure and constraints on population size, on the other hand, modern society put the process of human reproduction, that is the child bearing and rearing, into a completely private sphere, hence outside of social control, and also it has abolished traditional rules of social behaviours concerning human reproduction without replacing them by any new rules of its own.

Hence, in a sense modern society has destroyed both outside and inside systems to regulate the process of human reproduction and has made population change quite unpredictable. As already mentioned, the simple theory of check and balance between human population and natural resources has been disproved and no new satisfactory theory has emerged in its place. Some theories have been proposed which explain why the birth rate goes down as the income level increases, but it is not generally accepted nor strong enough to make any reliable prediction.

Now in the contemporary world we are faced with a very confused picture of population trends. In countries where the social system still keeps mostly traditional rules of behaviour concerning human reproduction, the population is growing very rapidly since the ecological checks due to epidemics and famine are removed by even minimal introduction of modern medicine and technology, thus destroying the balance between population and environment and also the foundations of the social system. On the other hand, in the most developed countries, the birth rate has gone down to such a low level that present populations will not be sufficiently replaced by the next generation, hence bringing about a long-term population decrease and a change of age structure. There is also a third type of country where population growth is accompanied by rapid social transformation.

In modern society, the process of human reproduction is considered to be a completely private matter and outside of any social control. But it is also considered to be the responsibility of society to provide everyone with a minimum level of sustenance and education, and here is a basic and far reaching contradiction, that is, society has the responsibility to take care of the people produced through factors completely outside of its control. Even the most centralized socialist regime did not dare to plan the number of births and deaths in a specified period.

The above fact has both behavioural and ethical implications. On the behavioural level, modern society has no definite rules of human behaviour in relation to human reproduction. It is generally considered that the basic unit of human reproduction is the so-called "core" family, consisting of a man and a woman living together solely on their free agreement, with their children, whose number is decided by their parents' (or mother's) deliberation. But such a concept can give little insight into the fluctuations of rates of human reproduction.

There is a basic contradiction in the concept of "family" in the modern society. Modern society is assumed to consist of equal and independent citizens with unalienable human rights. But who are the "citizens"? In reality, early modern philosophers who advocated such an idea considered the citizen to be a person with independent means of living, sufficient amount of property, and possibly a number of dependents. So the "citizen" actually meant the head of a family, with wife, children and servants, who are all dependants subject to the head, and without any independent means. Therefore, women and children, house servants, and also coloured people are excluded from the concept of "citizens." It is only in the 20th century that women have come to be full fledged citizens and so have household workers and minorities. But the case of children still remains problematic. In the past, the parents' right over children was absolute, and children could be the objects of benevolence and protection but did not have any independent "rights." Now children's rights as independent of, and sometimes opposed to parents' rights are discussed, but it is obviously impossible to treat babies and infants as fully independent "citizens." And sometimes society or the state is actually forced to intervene in the family and to restrict parents' rights in order to protect children from abuse by the parents.

But various branches of social science, especially economics, still treat the family (or the "family budget"in the jargon of economics) as an independent unit of consumption and labour supply with a single utility function, which means that it is completely under the control of a single person. Every husband now knows that it is a dream of the old days that he could completely control the expenditure of family members.

As for the problem of human reproduction, there arises the problem of how the process of human reproduction is managed. More precisely, how many and when children should be born in the family and how they should be brought up? In pre-modern times, such questions were not raised, since natural checks by high mortality and traditional modes of behaviour almost completely determined the whole process. But the modern concept of independent citizens forces us to regard all human behaviour, including human reproduction, as a conscientious action, and the progress of technology has made it possible to intentionally control the process.

But there has never been sufficient theory to explain how people will behave or to postulate how they should conduct the process of human reproduction. In the course of the history of modern society, modes and codes of behaviour related to sex and child-bearing have changed continuously, from the rigid and authoritarian attitude in the Victorian age to the rather libertarian ways of contemporary America. There does not seem to exist any clear image of the modern "core" family consisting of a completely independent man and woman (or even of a person of the same sex) with definite rules of behaviour related to sex and child-bearing. Now there is even the prediction that the "family" itself will disintegrate, being incompatible with the concept of independent citizens.

Another aspect of the contradiction in modern society is in the macro level of human reproduction. In modern societies, modern sectors (industrial and service sectors) have never been self-sufficient with respect to labour force. In the early stage of modernization, modern societies were provided with the labour force from the pre-modern agrarian sectors, where surplus labour forces existed abundantly. In the later period when the pool of labourers in the agrarian sector had been exhausted, supply and demand of labour balanced precariously. Sometimes there was a shortage supplemented by immigrants, and in other times the labour force was plagued by a persistent high rate of unemployment. In modern society human population is one of the most important of the renewable natural resources, but the nature of its reproduction process is not well understood.

If population is the central issue of the problem of sustainable development, we must have some means to control the size of population in order to achieve sustainability. But there are difficulties. The first is the uncertainty about the cause-effect relations in demographic changes, which make it difficult to predict the quantitative result of a specific policy measure. There is a rough correspondence between the level of per capita income and the birth rate, but vicissitudes of birth rates are hard to explain or predict precisely.

But more difficult is the question of ethics related to population control. The basic question, simply put, is that of who and what grounds can determine whether a new baby is born or not born? If we push the logic of individualism to its conclusion, we have to say that the right of choice to be born or not to be born must exclusively belong to the person and must be made by him or her before the birth. Of course, such a conclusion would sound too absurd. But then does the right of choice to bear or not to bear a new baby belong completely to the mother, as some feminists advocate? Or does the husband or the family head have some rights, as the old-fashioned will insist? Or should the community, society at large, or the state also be involved? Such questions are clearly unanswerable in one way or another.

Even if we consider the change of population size to be the concern of society, we still have the problem of who can determine the "optimum" or "desirable" size of the future situation. Overpopulation and also maybe underpopulation will cause misery or even disaster to the future generation, but does the present generation have the right to dictate to the future generation that it should have a "proper" size in order to be happy?

Even when population control is considered to be necessary and morally acceptable, there are still the problems of ethics surrounding the means to achieve it. It is usually considered to be out of the question to manipulate morality, but there are various ways of controlling births, some of which may be acceptable and others unacceptable on moral grounds. But more indirect methods through economic incentives and social propaganda, etc. may sometimes be considered dubious, infringing on human rights or being detrimental to social morals. Policy measures related to the "Single Child Policy" of the present Chinese government may well be condemned as a gross violation of basic human rights, but it can well be argued that no less stringent a measure could contain the population explosion of China, which could be a disaster not only to China but to all mankind.

There are also philosophical or ideological issues involved. The Catholic church still objects to any birth control measures as evil interference with providence, but then must the Catholics be exempted from any population control measures because of religious freedom? Some nations and ethnic minorities insist on the right of increasing their own numbers for ideological or political reasons. Can such arguments be completely disregarded when sustainable development is considered? The answer may not be simple.

As a conclusion, I again emphasize the importance of population in attaining sustainable development and also the difficulties and delicacies involved in the issue. I hope that its various aspects, especially the philosophical and ethical issues, will be discussed more vigorously and deeply.

# The Sustainable Society Project

*Also published in J. and R. Kasperson, eds. Global Environmental Risk (Tokyo: UNU Press)*

*Dr. John Robinson*
*Director, Sustainable Development Research Institute, University of British Columbia*

## 1. Introduction

As we move into the twentieth century, an essential priority for Canadians, as for citizens of other countries, is the development of sustainable and environmentally benign patterns of resource utilization and socio-economic development. The purpose of this paper is to describe one attempt to investigate the feasibility and impacts of a future for Canada that is based upon principles of environmental and socio-political sustainability. The Sustainable Society Project (SSP) explores the prospects for the development of a future Canadian society that is sustainable in environmental, economic and social terms. Through scenario analysis, the project traces the path of Canada from the present into a sustainable future forty years from now. It assesses the relationship among values, lifestyles, and technological and economic development in the scenario, as well as the feasibility and socio-political implications of the scenario itself.

The Sustainable Society Project emerges out of a particular Canadian context but reflects a more general interest in normative futures analysis intended to explore desirable rather than likely futures. The paper begins with a discussion of these theoretical and methodological issues. Because the project itself, which started in September 1988, is ongoing and is not expected to be finished until April, 1993 this paper contains only a preliminary report, describing the background, purpose, methods, and some of the initial findings of the project.

## 2. Background to the Project

### a) Concern with Environmentally Benign Futures

The conceptual origins of the Sustainable Society Project lie in the Conserver Society concept and research tradition in Canada. The term "Conserver Society" was coined in a 1973 report on resource policy by the Science Council of Canada (1973), which urged that "Canadians as individuals, and their governments, institutions and industries begin the transition from a consumer society preoccupied with resource exploitation to a conserver society engaged in more constructive endeavours."

The Conserver Society concept was first examined in detail by GAMMA, a research group based in Montreal. In several reports published between 1975 and 1979 (Valiskakis et al, 1975; 1976; 1979), the GAMMA group identified and explored three successively more radical Conserver Society scenarios: expansion with efficiency ("doing more with less"), a stable industrial state ("doing the same with less") and a "Buddhist" scenario ("doing less with less").

The Conserver Society concept was also followed up by the Science Council itself which published its major report on this topic in 1977, entitled "Canada as a Conserver Society: Resource Uncertainties and the Need for New Technologies." This report outlined five general policy thrusts: concern for the future; economy of design; diversity, flexibility, responsibility; recognition of total costs; and respect for the regenerative capacity of the biosphere. It also contained a detailed discussion of the specific techniques and technologies that might be adopted in the transition to a Conserver Society. Generally, these differed little from the changes described in GAMMA's expansion with efficiency scenario. However, the Science Council chose not to discuss directly the socio-political dimensions of the Conserver Society argument:

> We have tried to stick to practical matters, with an incremental approach, to identify some of the technological paths that lead in the right direction, toward sustained relationships with material resources and the biosphere. Whether those paths, about which in our view we do not have much choice, imply other changes can only be decided by Canadians through democratic discussion. (Science Council of Canada, 1977, p. 14)

The importance of the Science Council's emphasis upon technological matters was that it allowed them to argue that significant improvements in emissions reduction, land use and resource development practices, environmental protection, and efficiency of resource and materials use were all possible through improved technological development without significant reductions in material standards of living. This argument, which later became typical of a whole school of analysis in the energy and environmental fields, counterbalanced prevalent views that environmentalist approaches necessarily implied reduced living standards, and that such approaches amounted to resisting, rather than embracing, technological progress. On the other hand, such an approach precluded addressing other versions of the Conserver Society argument, such as GAMMA's second and third scenarios, which represented more significant changes in behaviour and development patterns.

The Conserver Society concept was not the only vehicle for environmental arguments in Canada at this time. A parallel exploration of the concept of "ecodevelopment" was undertaken in a series of meetings sponsored by Environment Canada and the Canadian International Development Agency (CIDA) from 1975 to 1979. The term ecodevelopment had been coined during the 1972 UN Conference on the Human Environment held in Stockholm. It referred to the notion of environmentally-sustainable development, and launched the "environment and development" debate that has been fostered since then by the UN Environment Programme. Ecodevelopment emphasized the need for: (a) meeting the basic human needs of people, (b) enhancing self-reliance, mainly at the community level, and (c) maintaining cultural and biological diversity through what would now be called sustainability practices (Francis, 1976; Sachs, 1977). Implicitly, ecodevelopment was viewed as something for the Third World, while the Conserver Society was for Canada and the industrialized world.

Although the Science Council's Conserver Society report and related activities generated considerable interest both in Canada and abroad, this interest did not translate into any official political or policy response. Instead, the concept itself became part of the ongoing political debate about environmental issues and futures that occurred during the 1970s. Perhaps for this reason, the Science Council downgraded their efforts in this area. While they published a 1983 discussion paper on the Conserver Society (Schrecker, 1983), no further research activity was undertaken and the concept was allowed to die a natural death.

Despite this lack of official interest or follow-up, the Conserver Society concept had a significant influence upon the development of environmentally-based arguments in a number of areas such as health (Hancock, 1980), and agriculture (Hill, 1985), as well as in providing a positive context within which to cast environmental arguments in general. Perhaps the most important area of application was in the energy field which, since 1973, had been the subject of intense political debate and interest. In particular, the emergence of the "soft energy path" concept, first articulated by Amory Lovins (1976a, 1977), became the vehicle for the most significant application of Conserver Society principles in Canada.[1]

Briefly put, the soft path argument suggests that demands for the services that energy provides (illumination, warmth, cooling, motive drive, mobility, etc), can best be met through a combination of increased energy efficiency and renewable sources of energy that are diverse, flexible, and matched in geographic distribution and thermodynamic quality to end-use needs. This implies a massive re-orientation of existing energy systems (and thinking) away from primary reliance on large-scale, centralized and non-renewable energy sources toward energy systems characterized by high levels of energy efficiency and the use of small-scale renewables.

The soft energy path concept spawned a series of energy analyses in various countries intended to explore the technical and economic feasibility of soft energy futures. In Canada, these culminated in a large province-by-province soft energy path study funded by the federal energy and environment departments and undertaken by Friends of the Earth Canada (1983/4). Using detailed scenario analysis, this study argued that under conditions of continued population and economic growth it would be feasible and cost-effective to operate the Canadian economy by 2025 using significantly less energy than in the base year of 1978 and supplying that energy largely through renewable sources of energy. However, by the time that the Friends of the Earth soft path study was released in 1983 and 1984, the world oil glut and associated price decreases had caused the focus of federal energy policies in Canada to shift back to a traditional concern with oil and gas extraction and revenue issues. Although an updated version of the soft path study was prepared and presented to the government (Torrie and Brooks, 1988), the soft energy path concept in Canada, and elsewhere, appears to have suffered much the same fate in official circles as the Conserver Society concept.

The exception to this general rule is that the energy efficiency arguments first articulated by soft path analysts have become influential in energy policy formulation across the industrial world (International Energy Agency, 1987; Canadian Electrical Association, 1991). Increased energy efficiency is now generally perceived to offer the best hope of ameliorating a whole range of environmental problems, including especially global warming.[2]

More generally, with the re-emergence of environmental issues typical of the mid-1980s, the publication of the World Conservation Strategy (International Union for the Conservation of Nature et al, 1980), and the Brundtland report (World Commission on Environment and Development, 1987), many Conserver Society ideas have re-emerged under the aegis of the sustainable development concept (Environment Canada, 1985). In particular, concern over global issues such as ozone depletion and global climate warming are stimulating renewed interest in exploring environmentally benign patterns of resource use and economic activity. The recently established International Geosphere-Biosphere Programme (International Council of Scientific Unions, 1987) and Human Dimensions of Global Change Programme (International Federation of Institutes of Advanced Study, 1989) are tangible indications of a growing interest in global environmental problems. On the political level, the 1987 Montreal Protocol on ozone layer depletion (Mackey, 1988), the subsequent more stringent measures, and the 20% $CO_2$ reduction target proposed at the Toronto Conference on

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1 In fact, before publishing the seminal soft path publications mentioned above, Lovins had published a paper in Conserver Society Notes based upon work undertaken for the Science Council, in which he had sketched out the outlines of a soft path energy future for Canada. Lovins called his two projections the Super Technical Fix model and the Conserver Society model (Lovins, 1976b).

2 With the exception of the electric power industry in certain regions, however, the energy policy response to these concerns in North America has been more rhetorical than real.

the Changing Atmosphere (Environment Canada, 1988) and since adopted by several countries, suggest a reorientation of the political agenda regarding environmental issues.

### *b) Methodological and Theoretical Issues*

Perhaps just as important as the growing interest in the substance of environmental problems has been the emergence of new approaches to the study of such problems. During the 1970s, it became increasingly apparent that traditional approaches to futures analysis and forecasting had a strong status quo bias and were essentially incapable of revealing or analyzing futures that represented significant departures from business as usual trends (Ascher, 1978). Again stimulated by the early work of Amory Lovins (1976a; 1976b), energy analysts began to undertake "backcasting" analyses that postulated a different and apparently more desirable future than that revealed by conventional forecasts, and assessed the feasibility and implications of such a policy path (Robinson, 1982a). Others began to develop and use non-predictive scenario analysis methods intended to alter the manner in which energy industry executives viewed the future (Wack, 1985a; 1985b). In a parallel development, researchers began to build energy "end-use" models based upon the depiction of physical processes rather than economic relationships. These models had the dual advantage of allowing non-predictive futures analysis of the backcasting or scenario analysis type and also permitted a much more detailed look at the potential for increased energy efficiency (Robinson, 1982b). More recently, the backcasting and end-use modelling approaches have been generalized beyond energy issues to encompass questions related to global change and sustainable development (Robinson, 1988; 1990a; 1991).

The growth in popularity of energy end-use models and non-predictive scenario analysis has been rapid. In the electric utility industry in North America, for example, end-use models have increasingly replaced the more traditional econometric models formerly used for load forecasting and now dominate the field. More recently, the emergence of environmental target-setting at the political level (e.g. for CFCs or for $CO_2$) has created a demand for methods of analysis that are intended to assess the feasibility and implications of reaching those targets (i.e. backcasting analyses).[3]

The emergence of backcasting and end-use modelling approaches occurred within the context of a growing distrust of business as usual futures and a corresponding emphasis upon openly normative preferred futures. This is part of a more general critique of traditional positive social science which argues for more "constructivist" approaches to the practice and evaluation of science and its use in the policy-making process (Robinson, 1988; 1990a; 1992). Recognizing the inescapably value-laden nature of all scientific analysis, such approaches try to make those values explicit and provide a means for their testing and evaluation, and for the identification of policy choices. This is particularly important with respect to what Salter (1988) has called "mandated science", that is science undertaken in direct support of policy-making.

Two major examples of mandated science are forecasting and risk assessment. Thus it is not surprising that the theoretical and methodological arguments made here with respect to futures studies have their parallel in the risk field, and indeed are based in large part upon the same substantive environmental concerns. (See, e.g. Wynne, 1987; Otway, 1987; Rayner and Cantor, 1987; O'Riordan and Rayner, 1991). In both cases a major emphasis is upon debunking the claims of traditional approaches to provide definitive technical answers to political questions (What is the most likely future? What is the objective risk?) and upon the identification of questions of power,

3 For a recent example of a backcasting approach to climate change issues at the regional level, see Jäger, et al, (1991).

credibility and choice (Who chooses? Who is expert? How is the problem defined?).

These parallels between the risk and forecasting fields are instructive for they illustrate the degree to which the arguments made in these fields are part of a larger dynamic related to the use of science for policy purposes.[4] In these and other cases of mandated science, one effect of the growing number of public policy debates about, say, energy futures or toxic waste disposal has been to call into question the very science used to support the various claims and counter-claims. In the energy forecasting field, for example, there exists a growing mistrust on the part of decision makers about the utility or even the meaning of large-scale and energy modelling efforts. In the risk field, the increasing use of quantitative risk assessment tools cannot hide the growing unease about their ability to resolve public policy disputes about human health hazards.

The "classical" response to this problem has been to focus attention on the scientific adequacy of individual risk assessment or forecasting studies: insofar as there are problems, they have to do with the quality of those studies, rather than with the approach itself. However, insofar as there exist problems with the way energy forecasting and risk analysis are done in principle, such individual critiques of specific studies will simply deflect attention from the underlying problems.

A more sophisticated response is to develop new approaches to risk assessment and forecasting that take into account some of the critiques of the approaches themselves. However, while such "neoclassical" approaches may introduce significant methodological improvements, they typically do not alter in any fundamental way the definition of the problem or therefore the overall goal of the analysis itself. For example, the emergence of interest in "risk communication," or the growth of more probabilistic treatment of forecast uncertainty, both reflect awareness of problems with the classical view of risk and of forecasting. However, such reforms do not challenge the prevalent view that science in principle tells us true things about the real world, that it should be value-neutral and objective, that the goal of science should be prediction, and that the basic problems at issue in public policy disputes are scientific ones which can be resolved through good scientific analysis.

An "alternative" approach to mandated science suggests that the problem lies not so much with individual cases of bad analysis or with improved methods of communicating science to policy-makers or the public as with a misconceived notion of what scientific analysis is and can provide to its users. This approach suggests that all mandated science is necessarily value-laden in the sense that its findings are influenced strongly by methodological and theoretical values embedded in its methods and approaches. From this perspective the goal of mandated science is not so much to find out true things as it is to make clear the points of difference, including value differences, between competing views of what the problem is. Put another way, the goal is to separate what is uncontroversial from what is not, and to make clear the underlying causes of the differences that exist.

The foregoing suggests that there exist at least three views of the role and status of mandated science: a traditional or classical view, in which the mandate and nature of the analysis is unquestioned and clear; a reformist or neo-classical view, which involves changes in approaches and methods in response to both the obvious failure of classical methods and the challenges from critics of mandated science; and a radical or alternative view, which challenges the very role and status of mandated science.

The Sustainable Society Project takes place within the context of these theoretical and methodologi-

4 For a detailed discussion of the parallels between risk analysis and forecasting, see Robinson (1990b).

cal developments. It has been designed to reflect what is called here the "alternative" view of the role and meaning of mandated science, in that its focus is upon exploring the feasibility and impacts of explicitly normative desired futures, within the framework of the perceived undesirability ("riskiness") of conventional business as usual futures. The project thus takes place against the background of both a resurgence of interest in environmental issues, and the emergence of new approaches to the study of desirable futures.

## 3. Purpose and Objectives

A sustainable society has socio-political as well as environmental and technological implications. The challenge is to analyze the implications of a sustainable society in an integrated way that accounts for both these dimensions. Moreover, the human and technological dimensions of a socio-economic system are dynamically interrelated; socio-political structures are reflected in technological and economic development and vice versa.

The overall purposes of the Sustainable Society Project are: to develop a scenario of the future development of Canadian society that is based upon principles of sustainability; to assess this scenario in terms of its feasibility, implications, and implementation requirements; and to contribute to the development of a network of groups and individuals interested in sustainable futures for Canada.

The Sustainable Society Project goes beyond previous research in Canada in several interconnected ways. First, the project provides rigorous scenario analysis of all sectors of the economy. Second, the project is not limited to technical fix solutions but will include analysis of lifestyle and social change. Finally, the Sustainable Society Project contains a detailed analysis of the links between sustainability values and socio-economic and technological change and development.

While the scenario analysis performed in the project involves multiple iterations to produce a balanced scenario, the project is designed to test the feasibility and impacts of a single Sustainable Society scenario. Although analysis of several alternative versions of a Sustainable Society and comparison to at least one business-as-usual future would have been desirable, such an approach was precluded by time and resource constraints.

The general approach used to integrate the various dimensions of sustainability in the project is to define sustainability as a normative ethical principle having both socio-political and environmental/ecological dimensions and then to develop scenario design criteria in each of these two areas that can be used to drive the scenario analysis. The intention is to iterate through as many attempts at developing such scenarios as are required to produce a reasonably consistent picture that conforms to the initial design criteria, and then to assess the feasibility, implications and implementation requirements of that scenario.

The specific objectives of the project are:

1) to develop socio-political and environmental/ecological design criteria for the scenario analysis that are based upon sustainability conceived as a normative ethical principle;

2) to create quantitative subscenarios of technological and economic development in the SERF modelling system based upon these design criteria and, through an iterative process, to integrate them into one physically consistent scenario of a sustainable future;

3) to determine and then evaluate the general social, economic, environmental and political implications of this final scenario, assess its overall feasibility, and analyze the socio-political

implementation measures required for it to occur, and

4) to contribute to the development of a network of interested groups and individuals in the field through involvement in the project.

## 4. Methods

### a) Scope

The project addresses sustainable futures at a national level. The spatial scope of the project is therefore the whole of Canada. International trade is addressed explicitly through the use of trade and balance of trade calculations.

Temporally, the scenario analysis extends forty years into the future, to approximately 2030, allowing sufficient time for the complete turnover of capital stocks, the generation of new structural relationships in the economy and the development of new institutional relationships in the political system. Comprehensive descriptions of the physical and technological state of the system are available for each year of the scenario evolution.

Sectorally, the scenario analysis focuses on demography (population, labour force and household formation), the various consumption sectors (dwellings, consumer goods, health, education, transportation, retail trade, office buildings, etc.), the manufacturing sector, and the primary resource sectors (energy, forestry, mining, agriculture, fisheries and water). Subscenarios of the sectoral subject areas are developed, based upon sustainability principles and scenario design criteria and then integrated into an aggregate scenario.

The impact and implementation analysis involves investigation of the consistency of the Sustainable Society scenario with project design criteria and assessment of the changing institutional relationships and political structures that might be expected to result from, and help to cause, the technological and economic developments described in the quantitative scenarios. This will involve an assessment and analysis of the compatibility of these evolving socio-political forms with each other, with principles of environmental sustainability, and with value principles basic to Canadian society.

The number and breadth of the subject-areas incorporated in the project requires a team approach. A core research team of five analysts, a number of graduate students, a group of other researchers with partial involvement, an advisory committee and a network of groups and individuals with an interest in the idea of sustainable futures are involved in the project.

### b) Theoretical Approach

Environmental problems pose important questions not only about scientific knowledge and technological change but also about social and political organization. As discussed above, this project is based upon the view that science and technology are deeply value-laden. Therefore it is necessary to examine closely the relationship between technology and social organization and between science and its use in decision-making, and it is also necessary to develop technologies and systems of expertise that are overtly grounded in the values that technology and expertise are intended to serve (Winner, 1986).

The result is an openly normative approach to the assessment of technology and social organization. In this project, that approach is represented by the linkage among technological development, social change, and sustainability values, and by the development of a scenario analysis method which can be used to express and evaluate different values and views of preferred futures. On this view, our role as analysts is not to determine what is the right course of action but to propose both our preferred alternative to current policy (which is explicitly grounded in a set of values) and a means by which others could propose and assess their own views and preferences.

The values forming the normative basis for this project are a version of those associated with the terms "sustainable society" or "sustainable development" (Brown, 1981; Clark and Munn, 1986). They imply a critical, or even radical, approach to technological and social development (Robinson et al, 1990). In order to assess the implications of these values and implement the normative approach to science, technology and analysis described above, it is necessary to use an analytical approach which departs from the predictive and ostensibly value-free orientation typical of most futures studies (Robinson, 1988). This project uses the "backcasting" method of scenario analysis discussed above. Backcasting involves defining goals, articulating them in terms of preferred future states of the system being analyzed, then attempting to construct a path of technological and social development between the present and the desired end-point (Robinson, 1990a). The goal is to assess the feasibility and impacts of normatively defined futures. In so doing, the analysis serves as a kind of consistency and feasibility check on the values in terms of which the normatively defined futures are constructed.

A unique characteristic of this project is its use of the SERF modelling system for scenario generation and analysis. SERF is an implementation of the design approach to socio-economic modelling (Gault et al, 1987). Design approach models are designed to examine the physical feasibility of alternative policy goals over the long-term (35-70 years). They can thus be used for backcasting analyses.

In modelling physical aspects of the Canadian socio-economic system SERF provides a disaggregated representation of stock/flow relationships and vintage, or age, characteristics of the energy, material and people in Canadian society. These relationships and characteristics are maintained in 43 separate submodels and over 1,700 multidimensional variables that are based on the extensive Statistics Canada data base. These models describe energy, labour and material flows in four major sectors: demography (population, household formation and labour force), consumption (housing, consumer goods, health care, education, transportation, offices, communications, and retail trade), production (detailed input-output and capacity models), and resource extraction (agriculture, forestry, primary energy, minerals and wildlife harvesting). The disaggregated and comprehensive nature of SERF allows the user to undertake detailed analysis of changing efficiencies, technological substitutions, labour productivity, etc. The user supplies input scenarios in the form of assumed future values for the approximately 1,700 multidimensional SERF variables, and SERF combines these time series inputs into integrated scenarios and assesses the physical consistency, over time, of the resultant overall scenario of the evolution of Canadian society.

While the existence of SERF allows the Sustainable Society Project to undertake detailed quantitative scenario analysis of a kind not hitherto possible, SERF does not encompass all dimensions of Canadian society relevant to this project enquiry. In particular, SERF does not describe the decision making processes and changing institutional arrangements that are associated with the technological/physical scenarios that it generates. Therefore, as discussed below, analysis of socio-political transformation is being developed outside SERF but connected to the scenarios generated in SERF.

### c) Research Plans and Project Method

The general analytical approach of the project is to articulate sustainability values, derive environmental/ecological and socio-economic scenario design criteria based on these values, develop a qualitative picture of Canada in 2030 consistent with these criteria, construct a quantitative scenario in SERF intended to describe a path between 1981 and 2030 that takes us to that future, and analyze the implications, feasibility and implementation requirements of that scenario (Figure 1).

In 1987, the project team was awarded $100,000 from the Social Sciences and Humanities Research Council of Canada (SSHRC) to undertake the Sustainable Society Project. In September, 1990 the

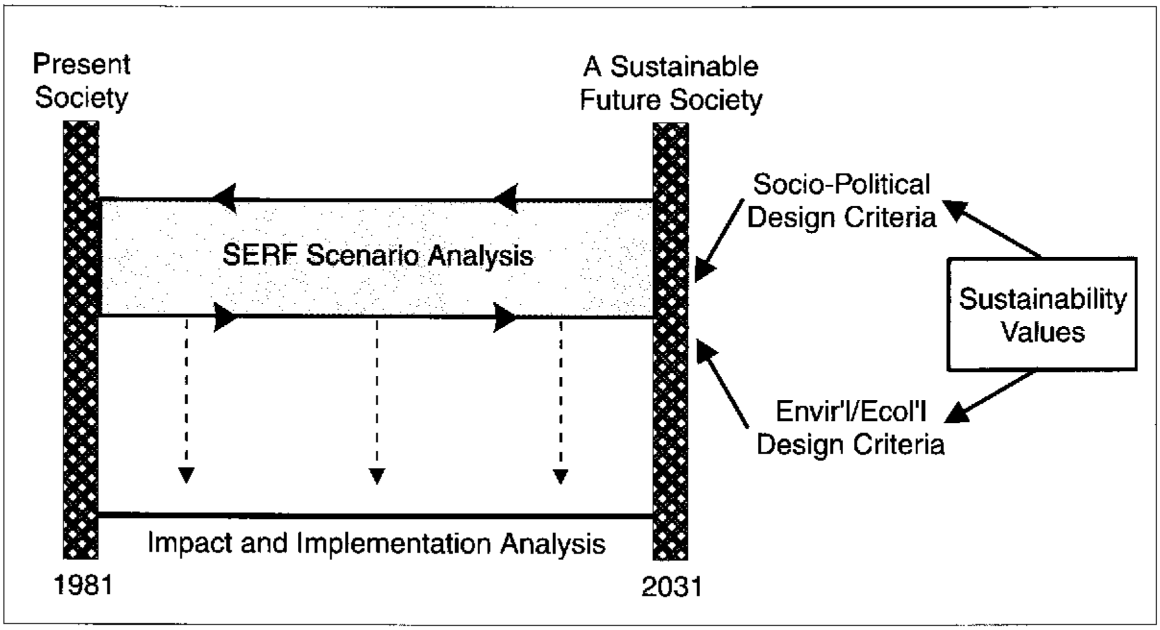


**Figure 1.** Sustainable Society Project conceptual framework.

project received a $25,000 contract from Environment Canada to continue work and in March 1991 we were awarded $110,000 from the SSHRC for another two years of work on the project.

The first step was to articulate and elaborate the values and principles underlying our sustainability scenario. These were described in the project's first Working Paper (Robinson et al, 1990). In that paper we have defined sustainability as a normative ethical principle with both environmental/ ecological and socio-political dimensions. On that basis we have articulated several basic value principles and a set of more specific ecological and social principles, as outlined in Table 1. These principles have been used to generate the environmental/ecological and socio-political scenario design criteria outlined in working papers #2 (Slocombe and Van Bers, 1991) and #3 (Lemer, 1991), and the description of economic, legal, political and individual decision-making in Canada in 2030 contained in working paper #4 (Robinson, et al, 1992). Over the summer and fall of 1991 detailed qualitative and quantitative descriptions of each sector of society over the period 1981-2031 were created, based on the contents of Working Papers #1-#4. These descriptions have been used to develop inputs to the SERF modelling system, as described in Working Paper #5 (McFarlane, et al, 1992).

Copies of all working papers are distributed to our Advisory Committee for comments, following which they are available upon request. Two more working papers (on agriculture and on energy systems in 2030) will be in draft form by September, 1992. Several other working papers are in preparation, and we plan to submit as many of the working papers as warrant it, for publication. (See Figure 2 for a depiction of the various Working Papers and their inter-relationships.)

The inputs to the SERF scenario take the form of quantitative time series over the period from 1981 to 2031 for the more than 1,700 multi-dimensional SERF variables, ranging over such variables as birth rates, labour force participation rates, housing and consumer durable consumption patterns, teacher-student ratios, doctor visits per capita, food consumption by food type, communications infrastructure, passenger kilometers by vehicle type, materials use in manufacturing, and primary resource extraction capacity and operation.

A complete Sustainable Society scenario was created and run on SERF in January, 1992. The results of this run take the form of scenario outputs which may or may not be internally consistent or

**Table 1.** Principles of Sustainability

### *BASIC VALUE PRINCIPLES*

- The continued existence of the natural world is inherently good. The natural world and its component life forms, and the ability of the natural world to regenerate itself through its own natural evolution, have intrinsic value.
- Cultural sustainability depends on the ability of a society to claim the loyalty of its adherents through the propagation of a set of values that are acceptable to the populace and the provision of those socio-political institutions that make the realization of those values possible.

### *DEFINITION OF SUSTAINABILITY*

- Sustainability is defined as the persistence over an apparently indefinite future of certain necessary and desired characteristics of the socio-political system and its environment.

### *KEY CHARACTERISTICS OF SUSTAINABILITY*

- Sustainability is a normative ethical principle. It has both necessary and desirable characteristics. There therefore exists no single version of a sustainable system.
- Both environmental/ecological and social/political sustainability are required for a sustainable society.
- We cannot, and don't want to, guarantee persistence of any particular system in perpetuity. We want to preserve the capacity for the system to change. Thus sustainability is never achieved once and for all, but only approached. It is a process, not a state. It will often be easier to identify unsustainability than sustainability.

### *PRINCIPLES OF ENVIRONMENTAL/ECOLOGICAL SUSTAINABILITY*

- Life support systems must be protected. This requires decontamination of air, water and soil and reduction in waste flows.
- Biotic diversity must be protected and enhanced.
- We must maintain or enhance the integrity of ecosystems through careful management of soils and nutrient cycles, and we must develop and implement rehabilitative measures for badly degraded ecosystems.
- Preventive and adaptive strategies for responding to the threat of global change are needed.

### *PRINCIPLES OF SOCIO-POLITICAL SUSTAINABILITY*

#### *a) derived from environmental/ecological constraints*

- The physical scale of human activity must be kept below the total carrying capacity of the planetary biosphere.
- We must recognize the environmental costs of human activities and develop methods to minimize physical throughput per unit of economic activity, reduce noxious emissions, and permit the decontamination and rehabilitation of degraded ecosystems.
- Socio-political and economic equity must be ensured in the transition to a more and more sustainable society.
- Environmental concerns need to be incorporated more directly and extensively into the political decision-making process, through such mechanisms as improved environmental assessment and an environmental bill of rights.
- There is a need for increased public involvement in the development, interpretation and implementation of concepts of sustainability.
- Political activity must be linked more directly to actual environmental experience through allocation of political power to more environmentally meaningful jurisdictions, and the promotion of greater local and regional self-reliance.

#### *b) derived from socio-political criteria*

- A sustainable society requires an open, accessible political process that puts effective decision-making power at the level of government closest to the situation and lives of the people affected by a decision.
- All persons should have freedom from extreme want and from vulnerability to economic coercion as well as the positive ability to participate creatively and self-directedly in the political and economic system.
- There should exist at least a minimum level of equality and social justice, including equality of opportunity to realize one's full human potential, recourse to an open and just legal system, freedom from political repression, access to high quality education, effective access to information, and freedom of religion, speech and assembly.

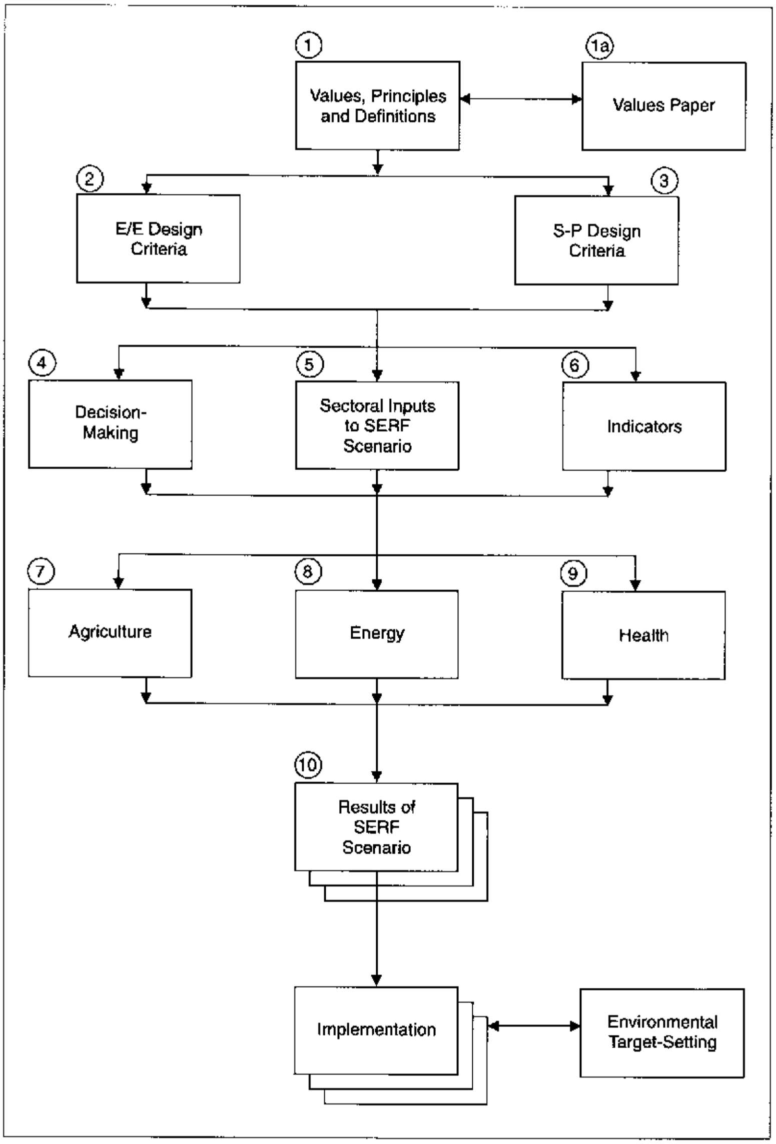


**Figure 2.** Sequence of SSP Working Papers.

consistent with project principles. The project team is currently working through the outputs of that run to assess internal consistency, and to ensure consistency with scenario principles and design criteria, and with the external analysis of changes in economic, political, legal and cultural decision-making.

The next step will be to consider the longer term policy options and changes in individual and organizational behaviour that would be associated with successful implementation of the project scenario. This will be initiated in an Advisory Committee workshop in May, 1992 and carry through the summer and fall. It is anticipated that one or more papers will be produced, organized by sector and decision-making categories, that will describe the types of changes required.

A key component of this stage will be several "policy workshops" in Ottawa. Their purpose will be to present the sustainability scenario and to discuss its implementation requirements with civil servants from the relevant departments affected and with stakeholders from other sectors of society. Preliminary discussions about such workshops have been held with officials from Environment Canada and representatives of the National Round Table on Environment and Economy. These workshops will be held in the winter of 1992.

Requirements for assessing the economic and socio-political impacts of the sustainability scenario are also under development. The general goal is to determine overall costs and impacts associated with the scenario, measured partly in terms of standard macro-economic indicators (e.g. economic growth, wealth per capita) and partly in terms of indicators of sustainability developed during the project.

The final phase of the project, to be undertaken in 1993, will be writing up and disseminating the results of the project.

### *d) Dissemination of Research Results*

The plans for dissemination of project results include, but go well beyond, publication in refereed journal articles. In the area of outreach and network support, we have created a twenty-six person Advisory Committee, produced a semi-regular project newsletter, and given a number of invited seminar presentations. The 12 project Working Papers we expect to have produced by the end of the project are available upon request as they are completed. Four papers on the project have been presented at various conferences. We currently distribute material to a mailing list of about 300 groups and individuals interested in the project. In addition, we have established four project "partners" from government and the para-public sector: the National Round Table on Environment and Economy, the Ontario Round Table on Environment and Economy, and the Sustainable Development Research Division and the Office of the Science Advisor of Environment Canada.

We expect that project working papers will be widely distributed to environmental NGO's across the country, and that the final product will serve as a lobbying tool for these groups in ongoing debates about desirable futures for Canada. In keeping with our general view of the science/policy relationship, we expect such lobbying use to be more productive than the submission of our results directly to government.

We see our proposed policy workshops as a major vehicle for both dissemination and evaluation of our research results. We expect that those workshops will be of substantial interest to government officials and to other participants. Through our partnership with the National and Ontario Round Tables, we also expect to reach interested parties in both the NGO and private sectors. We anticipate that the results of our work will feed directly into the ongoing research and policy activities of all these actors.

The Sustainable Society project is one of 40 international "21st Century Studies" being undertaken under the auspices of Jerry Barney's Institute for 21st Century Studies in Washington D.C., through which we maintain contact with many researchers in other countries producing environmentally-oriented long-term futures studies.

In a more conventional way, we propose to publish components of the project in various forms. Our first working paper has been published in *Alternatives* and we propose to submit working papers to appropriate journals. We will be presenting papers on the project at conferences, as appropriate, and plan eventually to produce a book-length description of the project.

## 5. Conclusions

The Sustainable Society Project is an ambitious attempt to tie together some of the diverse threads of the environmental arguments that have developed from the Conserver Society tradition in Canada. In so doing, it represents an application of a set of methodological approaches and principles that have emerged out of the same tradition. It was, in fact, the perceived need to develop methods of analysis oriented toward the examination of unconventional futures that led environmentalists and soft energy analysts to develop backcasting approaches and Statistics Canada researchers to develop SERF. The Sustainable Society Project combines these methodological and substantive approaches in an integrated analysis.

It is clear that this project can only provide a preliminary assessment of the feasibility and impacts of a sustainable future for Canada. In so doing, however, it can contribute to the ongoing debate about such futures. Of course, no futures analysis of the type proposed here can be definitive or exhaustive. At best it can reveal the rough outlines of a desirable future, and suggest that such a future seems feasible and therefore worth striving for.

This does not mean that the analysis, and analysts, have no role in the political debate about desirable futures. It does mean, however, that futures analysis should not substitute for decision-making. The role of the futures study is to explore various versions of possible futures, and to indicate their apparent feasibility and implications. The rest must be left, as it should be, to the political process.

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## General Discussion 1

**Kei Takeuchi:** I have one question. I think I completely agree with the general line of thought the present speaker gave but I would like to emphasize only one point, that is in considering environmental issues, the most important factor is the time scope. How long is the time period we are going to consider? Some people say that since the global environment problem is very long term, we therefore have to consider periods of 100 and even 200 years. But I think that is quite wrong, quite meaningless because we cannot say anything about technology's progress or social economic changes in the future 200 years. It is simple to see if you look back 200 years during history and I should say that 200 years ago Canada did not exist as such. In the future 200 years, I don't know whether the United States, Canada, or Japan will exist in the present form. So I think 50 years is the longest you might foresee. But then the problem is that in fifty years I think we really cannot attain a sustainable society as such, because I think everything cannot be categorized in such a short period. I see in the case of Canada, for example, that the population is going to be stable during the next fifty years but in the world as a whole it is hoped that the population will be stable *in* fifty years. I think that while dealing with such a transient state the problem is too difficult to consider in any longer terms than 100 years from now. The study also seems to be a little bit, so to speak, ethnocentric, from the viewpoint of Canada alone. I think. Maybe I am wrong, would you respond?

**John Robinson:** No, I think you are right. In a sense this is a reaction we had before talking about this work internationally. It's easy. Here we are talking about a rich and industrious country with a stabilized population which isn't at all the global situation. I guess my response is that it is not even clear that we are doing it right in Canada or we are even thinking seriously about these issues. If we can't do this here it is going to be a lot harder, I suspect, to manage doing it on a global scale. That's why I think it is so important to begin the discussion about these long-term futures and the only answer I can give to this time frame problem, which is a big problem, is to say what the global climate exchange people have when dealing with policy makers. There are two points.

One is there are things we want to change anyway. There is lots that's wrong now. It is not like we have to wait to find some problems to deal with. There are lots of them we can start on. And secondly is the resilience argument. We should be starting on problems in ways that take into account the long term future. But you are absolutely right. Canada can do everything right whether it's arsenic or not, its not going to help the planet very much. We have to also be thinking very seriously about countries in very different kinds of development paths. The work of Josie Goldenberg in Brazil and others starts to address those concerns.

But you are right. We had an easy case in a sense to deal with. But the high consumption patterns of Canada are the issues.

**Lawrence Morley:** Let's go back to the basic premise. What determines our future is unexpected technological advance and here all we have to do is look at history. We go back to the invention of fire, the invention of the wheel, the industrial revolution etc., nuclear energy, all of these developments were completely unexpected. They controlled, absolutely controlled our future and we had to adapt to these new technological developments rather than say: let's look at it from present knowledge of technology to see what is going to be our future and look at various scenarios and try to choose our future. I submit that unexpected technological advances are going to change our future more than we can possibly imagine.

**Unknown Speaker:** I agree with the last statement that unexpected technological advances are going to change our future more than we can imagine. That's why prediction is not a very useful approach to take. Precisely. However, I think we do not agree about the idea of control. I think nuclear power is a good example. In fact, I think of any technological advances, nuclear is perhaps the best example. What we have is technological innovation that has surprising consequences but those consequences are not determined. Nuclear power was supposed to lead to energy too cheap to meter. It hasn't because of cultural, economic, social, and political factors that have made it unacceptable. Mainly economic but also political reasons.

So there we have a situation where a new technological development that at least to its adherents promised vast changes, energy too cheap to meter that would fundamentally alter the nature of human existence on this planet. But it didn't come to pass. The technology did not drive it. It was driven instead by other social and economic forces. So I think the lesson with that, and I think you could multiply those examples, is that technology changes everything but it doesn't determine the nature of those changes. Yes, the changes are huge and unexpected, but the form they will take is partly a matter of choice. We are constrained. I think we are constrained ecologically—we are constrained culturally, economically and technologically. But that constraint does not contain us to only one path. I think there are significant choices that can be made within those constraints.

**Kei Takeuchi:** I think I can agree basically but it is again time span that is important. So I am not worried about 200 years in the future because then maybe what technology supplies can save us. But I think in the prospective future of maybe 50 years we cannot simply assume that technological progress would save us from every trouble and I think also that we can safely predict the possible trends in the near future and new possibilities for the next 30 or 50 years. Not necessarily for the very basic reason of the slowness of the technological progress of science and technological knowledge, but also we can safely assume the social, cultural and economic factors will continue to determine the speed of technology and especially implementation of technological progress. So that I think you still have to think about how we are going to use these kinds of technology and cope with the problem of environmental resources.

**Jack Cornett:** I work for AECL Research. I have sort of a two component question. Models are always fascinating but one thing that is useful at least with physical models is to look at how sensitive they are to the key assumptions or parameters. I am wondering, whether in the population world or in the sustainable development world, about the types of models you are both using and if this is a useful approach. If you do that, what is the sensitivity, what are the most sensitive parameters and how long does it take in both situations to reach some sort of steady state? What determines the time to that steady state?

**John Robinson:** In the case of modelling framework, we use a physical accounting modelling framework where it has the opposite nature of a micro economic model or strategic based models which idealized behaviour and are strategically based on analyses of past relationships in order to drive predictive capability. It is all supplied by end put. All the equations are tocological in the system, except the input/output table, which is as close to tocological as you can get to describe an economy.

So the idea of sensitivity testing doesn't apply in terms of model validating, it does apply of course in terms of testing alternative configurations and what happens. Again the what if configuration. We did a fair bit of that at a micro level. What we had hoped to do was alternative macro configurations of the system, changing some key variables and seeing which ones were most important in determining the outcomes. We ran out of resources before we could get to that stage. So what we have here is a scenario that we know is physically consistent but we have no way of testing its micro economic consistency in terms of say, prices. So we know that we are mining enough coal to make the steel, to make the rails we need for the number of rail commuter passenger rail vehicles there are. That kind of physical consistency is ensured. We have energy supply and demand, labour supply and demand, and material supply and demand that are physically consistent. But we weren't able to do the kind of alternative configurations that we would have liked.

**Unidentified Speaker:** I would like to raise one question which is really for all the attendees here today, because we are talking about technology and this has raised the issue of the "surprises" of technology. A lot of the surprises that have been seen in hindsight are quite unpleasant. Just to put forth some of the obvious ones: CFCs which were seen to be useful are now destroying the ozone layer; PCBs were also seen to be good, but are building up in the food chain. What I think a lot of people would like to know is how people who are experts in the field of technology are going to try to provide assurance that we are not going to find even more unpleasant surprises in the future. Otherwise I think technology will be seen to be not a good thing, but in fact something which is bad.

There is just one other question I would like to leave with you. For John, very briefly you have put forward a series of possible scenarios that you could offer. We are heading into a period of political change. There will be a new government of some shape within a week. How saleable are these approaches to the political system. In other words, is it realistic for someone like yourself or others, in Canada or other parts of the world, to come forward and say if you follow these patterns of development, you will probably have better outcomes ecologically. I don't get any sense from the political arena. I wonder if you do?

**John Robinson:** I think my comment to the second comment, Michael, would be somewhat similar. After years of looking at the ways science gets used in public policy-making, I have come to the conclusion that the big influence in the environmental arena has been from public concern, not from research results, in determining what policies get adopted. So I think the answer is not that politicians in particular are going to start listening to scientists. Science has only ever been one small input into a really complex interest-balancing game that is quite successful despite the common attitude in the research community that politicians are kind of ignorant—that they need to learn science so they can make good decisions. I think that is just naive. The much more interesting approach to take is to recognize that it's the public concern that drives the political agenda. Therefore, what's important is a populace that is engaged and interested. Not just senior decision-makers like I suggested earlier. I think we need to use the new technological advances, say in the area of gaming, simulation tools, and especially through this growing generation of teenage computer literate kids, to develop tools that will allow the kind of situation wherein five years of analysis tucked away in a room with a big computer can be spread out into the populace at large. We need tools that will allow people to explore really long term choices in an environment that they can play with and come to their own decision about, and then that feeds into the political process through all of the normal routes.

That's my own, perhaps pollyannaish, view of the way we can address that concern. Not go to politicians and say here's the answer. That doesn't work. It probably shouldn't work.

# 2. Physical Dimensions of Environmental Change

*Chairperson: Dr. Brian Bornhold, Director, Canadian Global Change Program, The Royal Society of Canada*

## Environment Monitoring From Space

*Dr. Mikio Takagi*
*Professor, Research Institute of Industrial Science, University of Tokyo*

Earth environment problems have been a major issue all over the world. The decrease of tropical forests, erosion, desertification, the greenhouse effect caused by increasing carbon dioxide, acid rain, the ozone hole, the unusual weather due to El Niño and so on have become everyday topics. Human activities very heavily affect the earth system, in which atmosphere, geosphere, hydrosphere and biosphere are closely related to each other in a complex manner.

The scientific research to observe, understand and predict the earth environment from the global point of view is going on under the name of "Earth System Science" in the United States. To promote earth system science and continuous global earth observation in the long term, the establishment of an information system on the global earth environment and the development of numerical models to predict various phenomena on the earth are mandatory.

From the aspect of continuous global earth observation in the long term, remote sensing from space using satellites has been contributing to precious information on earth environments since the meteorological satellites "TIROS" and the ERTS (Earth Resources Technology Satellite, now known as LANDSAT) were launched in 1960 and in 1972, respectively. Under the name of "Mission to Planet Earth" various projects—SeaWiFS, RADARSAT, TRMM, ADEOS—are under development, and especially polar orbit platforms (POP), with earth observing systems which have been planned since the late 1990's by the United States, Europe and Japan. These programs will provide much more capable global observation of earth environments and deepen our understanding of our earth.

To understand the earth system, remote sensing from space is very effective and plays an important role. Earth observation from space by many satellites, for example, geostationary meteorological satellites such as GMS, GOES, METEOSAT and INSAT, and polar orb it satellites such as NOAA, LANDSAT, SPOT, SEASAT, NIMBUS, HCMM, MOS, ERS, and J-ERS, have been offering a lot of very important information on the global earth environment.

Earth observation from space has the following advantages:

(1) *Global observation*—Geostationary satellites provide whole earth disc images. In the case of polar orbit satellites, the resolution on the earth and scan swath change depending on objectives. NOAA satellites observe a 3,000 km width with 1 km resolution at the nadir. Land observation satellites, narrowing their scan swaths, observe from 10 m to some 10's m resolution. Earth observation from space makes wide area observation with high resolution possible.

(2) *Periodic and long-term observation*—Observation frequency depends on the objectives of observation. Meteorological satellites for observing meteorology, which may change very rapidly, observe every hour or every 30 minutes if necessary. In polar orbit satellites, NOAA

satellites designed for ocean observation cover wide areas with 1 km resolution every 6 hours by two satellites, whereas LANDSAT and SPOT for land observation observe the same location at the interval of more than 10 days with high resolution, narrowing the scan swath, since their objects (land) require high resolution, but phenomena on land do not change so quickly.

(3) *Data acquisition with uniform quality and repeatability*—Since sensors on board are calibrated before launch and on board calibration data are transmitted to the earth with observation data, acquired observation data have uniform quality and repeatability. Of course, observation by optical and infrared sensors suffers from atmospheric effects.

(4) *Observation by various types of sensors*—The same location can be observed by various types of sensors and various satellites. Optical sensors in visible, near infrared and thermal infrared regions, passive microwave radiometers, active synthetic aperture radars, microwave scatterometers, microwave altimeters and so on are on board according to the observation mission.

Earth observation from space has the following features: multi-sensor, multi-spectrum, multi-temporal, and multi-resolution by multi-satellite.

There are many problems, however, to be solved:

(1) *Preprocessing*—In preprocessing, satellite data need radiometric correction to calibrate sensors and to estimate atmospheric conditions to remove atmospheric effects, and geometric correction for registration and mapping. Sophisticated algorithms should be developed for each sensor.

*(2)* *Understanding of the relation between observed physical parameters and objects*—Observed data are converted into physical parameters. Understanding the relation between observed physical parameters and objects is very important and requires a lot of basic research. Ground truth is necessary to understand the relation between physical parameters and objects. And combination with other data such as GIS (Geographic Information System), meteorological observation, hydrological observation, and other statistical data, is essential to better understanding of earth environments.

*(3)* *Very high volume data (Data Management)*—It is said that the data volume of earth observation per day will be more than 1 TB ($10^{12}$ Byte) in the era of earth observation platforms. New information systems should be developed to process, to archive, to retrieve and to analyze such a tremendously huge amount of data.

In the early 70s I realized the importance of NOAA satellites and tried to utilize the data for academic research. Then, the NOAA series satellite moved to the next generation in 1978. It was so difficult for users to access the data in Japan that I decided to build a receiving station at my laboratory in 1980 and the data have been distributed to academic researchers without any charge. As a result, research in oceanography has especially been promoted. Since April 1992 our station has been sending all NOAA satellite daytime data to the EROS Data Centre to contribute to the 1 km AVHRR Land Project, which collects all daytime NOAA data from all over the world for the International Geosphere-Biosphere Programme (IGBP) to monitor worldwide land vegetation. The EROS Data Centre requested us to contribute this program to cover the Far East.

Since it seemed to me that in Japan basic research to apply satellite data to academic research on earth environments such as atmosphere, ocean and land was very poor and the research structure was very weak, the Special Research on "Higher Order Utilization of Remote Sensing Data from Space" was organized in 1985 for a period of three years, with researchers specializing in microwaves, data processing, oceanography, meteorology and land, covering everything from basic research to applications. As a result, a group with close cooperation between scientists in the geosciences such as oceanography and meteorology, and in engineering, such as data processing and remote sensing, was set up and research was promoted at a high academic level. Through this project the importance of earth observation by satellite was recognized and a decision was taken to propose a priority area program to promote academic research corresponding to the trends where satellite observation became very active internationally, towards the 90s. The Priority Area Programme on "Better Understanding of Earth Environment via Satellite", funded by the Ministry of Education, started in 1989 as a three-year program. One hundred and fifty academics with an interest in earth environment satellite data joined the program.

The features of this program lay in the promotion of academic research from a new viewpoint, and common basic research to support it. Problems in boundary areas, which had not been studied well by traditional independent scientific fields such as atmosphere, hydrosphere, and geosphere, were the target of this research programme. Selected were: the boundary area between atmosphere and hydrosphere, remote sensing of air-sea interaction system; the boundary area between atmosphere and geosphere, remote sensing of evaporation, and exhalation-snow and rainfall interaction system; and the boundary area between hydrosphere and geosphere, remote sensing of water circulation and soil moisture. As common basic technologies essential to the research on boundary areas, research on measurement and information processing was promoted. As for measurement, microwave remote sensing was selected, because it was expected to play an important role in future earth observation of the atmosphere, hydrosphere, and geosphere, but so far its basic research had not been well studied in Japan. Another common basic technology, advanced information processing, which is essential to promote research on the atmosphere, hydrosphere, and geosphere, but had not been well developed, was picked up. The following five research plans were selected:

- *A Basic Study on Earth Observations by Microwaves*
  Leader: Haruto Hirosawa (Institute of Space and Astronautical Science)

- *Global Change Analysis of Biosphere Using Satellite Data, Interaction between Atmospheric and Terrestrial Aspects*
  Leader: Shunji Murai (Institute of Industrial Science, University of Tokyo)

- *Study on Physical Process of Water Cycle over the Land*
  Leader: Junsei Kondo (Geophysical Institute, Tohoku University)

- *Study of Air-Sea Interaction Using Satellite Data*
  Leader: Yasuhiro Sugimori (Faculty of Marine Science and Technology, Tokai University)

- *Higher Order Processing of Earth Observation Information*
  Leader: Ryuzo Yokoyama (Faculty of Engineering, Iwate University)

Working groups, such as Geographic Database, Eco-climate Map, Ozone, Water Circulation in Terrestrial Regions, Ocean Colour, Workstation and NOAA Satellite Data Analysis, were established to promote research on the common problems in group or inter-group problems.

From the experience of the above two projects, it has been realized that construction of an infrastructure for earth environmental research is essential to promote scientific research, because satellite data are too far from their users. Research on global environments needs a lot of processed data to study the earth's phenomena, which changes dynamically in time. Scientists require many processed data for their research. Currently, almost all global data sets are supplied by the United States and it is owing to and based on their data that our scientists are doing their research.

Therefore, we proposed a new Priority Area Programme on "Construction of Information Systems for Earth Environment and their Applications" to the Ministry of Education, but it was not accepted, because construction of an infrastructure did not meet the concept of the program to deepen academic research within three years. I think, however, basic research on earth environments needs a good infrastructure. Instead of approval of the program, the Ministry of Education will give support to enhance my ground station and processing facility probably in the next year fiscal year. I hope this becomes a pilot experiment to build better infrastructure.

Canada and Japan have RADARSAT, ADEOS and TRMM projects to contribute to earth environmental monitoring. ADEOS (Advanced Earth Observing Satellite) will provide two main sensors; OCTS (Ocean Colour and Temperature Scanner) and AVNIR (Advanced Visible and Near-Infrared Radiometer) and AO (Announce of Opportunity) sensors; NSCAT (NASA Scatterometer: NASA/JPL), TOMS (Total Ozone Mapping Spectrometer: NASA/GSFC), POLDER (Polarization and Directionality of the Earth's Reflectances: CNES/LERTS), IMAG (Interferometric Monitor for Greenhouse Gases: MITI), ILAS (Improved Limb Atmospheric Spectrometer: Environment Agency) and RIS (Retroreflector in Space: Environment Agency). TRMM (Tropical Rainfall Monitoring Mission) will be launched and operated cooperatively between the United States and Japan. Japan will provide PR (Precipitation Radar) and the United States will provide VIRS (Visible and Infrared Scanner), TMI (TRMM Microwave Imager), CERES (Cloud and Earth Radiant Energy System) and LIS (Lightning Imaging System). The Japan Aeronautical and Space Industries Association announced a proposal of WEDOS (World Environment and Disaster Observation System), which consists of 26 polar orbit satellites for observation (24 sun synchronous and two sun non-synchronous satellites) and 12 geostationary satellites for data relay. For these satellite programs, it is very important to promote basic research on sensor design, sensor calibration, validation, utilization to science, and data management aspects such as processing, archive and database. Without basic research, satellite data are just pictures. Basic research gives physical meaning and validation to the data and a better understanding of the earth environment becomes possible. In Japan, basic scientific research on environmental satellites has not been organized or well supported. Cooperation between Canada and Japan in basic research is necessary for better utilization of satellite observation.

From my background in electronics, I would personally like to propose close cooperation between Canada and Japan in information systems for earth environments based on satellite observation. As mentioned before, there are many problems to be solved in the preprocessing of satellite data and data management. Satellite data are processed from Level 0 (raw data) to Level 3 (purpose-oriented data; for example, sea surface temperature) via Level 1 (annotated data) and Level 2 (radiometrically and geometrically corrected data) step by step. Processing in each step above Level 1 needs a lot of computation, and feedback to the data processing side is necessary, if any better algorithm has been developed by scientific users. Since data should be cheap and free to use for academic research, an experimental trial for NOAA, SeaWiFS and GMS satellites is under development at our laboratory. A system for currently available NOAA data is under development as the first step. And as receiving stations for SeaWiFS and GMS are under planning, the system is going to include these data for academic users.

The first stage is designing and realizing data archives for raw data. The next stage is how to realize a user-friendly database for scientific users, and a hierarchical database structure may be a solution. Also, access to data archives and a database for remote users via academic computer network should be realized. A database system for global environmental research needs a new conception, because global environmental research requires numerical point data such as statistical data, climate data, hydrological data, ship measurement and so on, two-dimensional data such as maps, digital elevation, various kinds of GIS (Geographic Information Systems) and satellite derived imagery. Therefore, a new multimedia database is essential to integrate these data. In the near future, a data centre for global environment research will be provided. It may consist of purpose-oriented distributed databases connected by a high-speed network.

I think Canada and Japan should cooperate in making a global data set on the earth environment and exchange their experience in regional studies. And it is needless to say that cooperation in the science and technology of remote sensing in every aspect should proceed. But, from my personal view, cooperation in information systems for global environmental research is extremely important, because it is the fundamental infrastructure. Nevertheless there still remain a lot of problems to be solved. Canada and Japan have very high potential in computer, communication and multimedia technologies. Since new information systems for environmental research need high speed processing, a multi-media database, very high speed networks and their integration, cooperation of both countries in this field will make a great breakthrough in information systems and contribute to all the world.

## Climate Change Research in Canada

*Dr. Kirk Dawson*
*A/Assistant Deputy Minister, Atmospheric Environment Service*

It is a pleasure to come and talk about one of my favourite subjects, climate change, and to talk a little about the research that's going on in Canada on that subject. I think you are all aware that fifteen years ago the scientific community set out to look at two questions.

The first question was: "Is climate in any way, shape or form predictable?" Secondly, "Is human activity in any way likely to be able to change those future climate systems?" About half-way through, a third question got posed and that was, "If the climate system did change, did it really have any implications for humankind and society?" I think the answers to all three questions have very much been a resounding yes, and I think Canada has played a substantial role in researching all three of those questions. The basic model that one has used has been a model of the climate system—basically a heat engine being to a degree driven by the greenhouse effect and amalgamation of that greenhouse effect. In Canada we have looked at that question, and from the modelling results that we have developed, this is the sort of a temperature change that one might expect to see in North America as a result of the doubling of $CO_2$. This is an equilibrium experiment, we don't say when that will happen. That question is very much a question that John Robinson is in a much better position to answer than I am, since it is a question of economics and societal action, rather than a question of climate. The interesting aspects of that are that it's a very nonuniform response within Canada—a very substantial degree of warming both in the lower prairie region and very much in the high Arctic.

Those are the sort of pictures that I presented one day to a cabinet committee on Parliament Hill. It was January and it was -35°C and they said, "Why the hell should we be worried?" Well I did have a follow-up slide and the follow-up slide did talk a little bit about the socio-economic implications associated with that degree of warming. Now these studies were undertaken over the last five years, very simplistic studies if I may call them that. They keep everything constant except one thing and that's basically the change in temperature. That is not a very realistic assumption, however it does give you a first degree of approximation and the thing about the different colours is green is meant to represent a benefit, and red is a potential problem. Interestingly enough those factors basically balance and that's because I had to convey the information that there are benefits as well as drawbacks from a global warming perspective.

I have over the last two years been more concerned with fish migration as an issue that needs to be looked at a lot more closely. The issues in the West are seen in terms of forest change and logging practices change. Clearly a warmer climate with more $CO_2$ is going to give you a greater crop growth. There was only one caveat to that and that is it will happen providing you can keep enough water in the prairies to keep the crops growing.

Those are some of the positives and negatives. What is the basis of our understanding on this subject? I think there really is not a great debate these days about the causes of atmospheric change. I think there is a reasonable consensus on the magnitude of global warming being somewhat in the range of two to four degrees for each doubling of $CO_2$.

The timing is much more problematic. Again, I say that is more of a question of economics, and we got ourselves into a great deal of difficulty when we first started this work by defining a business-as-usual take. Because as John said earlier this morning, there really is no such thing, but you are forced to use that type of an argument when you are making these types of calculations. You may note that all of the work is very very quiet as to what happens with precipitation. One of the things that has become a revelation to me in the last year or so is that people are far more interested in what's happening to precipitation than they are in temperature. And yet the community at large is very silent on that same question. I think scientifically we may agree that it's a positive sign. In terms of the scale of the issue, globally it's not too bad and regionally the uncertainties are starting to creep in. Locally, which is where everybody is really interested, we are totally silent on. I will come back to that particular problem.

In terms of how governments are responding, the Canadian response has been effectively a three-fold approach. One part is to continue to work on a reduction in the uncertainties, not just a reduction in the scientific uncertainties with the climate system, but a reduction in the uncertainties in socio-economic response on how one deals with that. As that uncertainty is reduced, we see a gradual and increasing effort in the area of limitations activity. As the scientific certainty grows, then I think governments are going to be willing to take more and more action.

But at the same time, in our view, there is a need for adaptation, because no matter what we do on the limitation side, we are still going to have some significant degree of warming over the next period. Therefore, we must improve the resilience of our social and economic systems to a climatic change. So the government's basic response is in those three areas.

In introducing this program, the first two were relatively easy to argue for. The third one, which I thought was going to be the simplest one to get support for, turned out to be the most difficult. I guess I need to go back to school to learn something about political decision making, to ascertain why that might or might not be.

The Canadian global warming program has, in fact, a component to limit emissions and stimulate international action, improving understanding and, as I say, anticipating and preventing. In the area of limiting emissions a significant amount of work is going on in federal-provincial relations in terms of planning this response. Canada being a federal system, almost all of the actions that have to be taken towards a limitation of emissions have to be taken by the lower levels of government. This means that you enter into a significant dialogue between the federal government and the provincial governments. Of course most of the actions have to be taken by departments other than environment departments. The key is in the policy halls of the energy departments where the substantive decisions have to be made. Given the political dynamic within Canada, that means we must achieve the agreement of 26 ministers in order to take a certain degree of action. I always found that getting two to agree was an impossible task, 26 seems to be pushing it a little bit. However, we are making progress there and it is proceeding at a pace that creates impatience in the minds of many, but given the complexity, I think it is moving forward effectively.

The key is improving efficiency, and as John said earlier this morning there are many opportunities with the technology available today, an apparent economic benefit to deal along with the commitment of the government of Canada to a goal of stabilization of emissions. But the institutional barriers to implementation appear to be substantial. The promotion of alternative energy; we have programs in that area. They are not as aggressive as many would like to see.

The key is information and the challenge to Canadians is to take the actions that are necessary. This is supported by tree planting, agricultural practice change and working on CFCs—that is on the local side.

On the international side, I think almost all the countries in the world have signed the *Framework Convention on Global Climate Change*. That convention I would anticipate will be coming into effect in the fall of this year or early next year. I was delighted to read the other day that the *Biodiversity Convention* has actually now achieved its quorum of supporters and therefore goes into effect later this year. I had originally hoped that the climate convention would be in place first but it needed fifty supporters—on biodiversity we only needed thirty. The international convention continues to move forward quite effectively.

On the question of improving uncertainties and participating and preparing, these got rolled into one program. In essence, what we are looking at is forecasts, participation in large scale experiments and development of the next generation of climate model. We continue to work on the socio-economic impacts, and also to look more at the question of whether or not we have actually seen any climatic change, and if so how much and in what areas.

In terms of the participation in large-scale experiments, we are going to be working on ocean heat transport through activities of the Department of Fisheries and Oceans. We are going to be doing a significant amount of work in the whole area of precipitation and cloud formation. We have done a lot of work on the sources and sinks of greenhouse gases and will continue to do that. In that area we're looking particularly at the role of the boreal forest as a source and a sink of $CO_2$. We have done the same thing with wetlands, looking at methane emissions, and I think as some of you may be aware, we were extremely surprised at the relatively low rate of emissions coming from the Canadian wetlands. They were a lot lower than what we had predicted.

In terms of a next generation climate model, we are looking at the addition of ocean and other processes to the models. This is anything but a simplistic problem. We have developed an ocean modelling capability by working with our colleagues located at the University of Victoria. We would anticipate having a coupled ocean-atmosphere model working within the next year or so.

A key requirement being stated to us is to increase the resolution of these models. To deal with a gradual augmentation of the gases. To assess variabilities and to run some scenarios. This question of scale was shown by the previous speaker—that's how North America looks to the current GCM. A little bit of a hodge-podge, there's one square I think that actually has the Great Lakes in it. You don't have a great deal of confidence with models when they are operating at that scale. So we are hoping in the next version to have a North America that looks something like it is, where you can actually see that the Great Lakes, and the Rocky Mountains do exist in between British Columbia and Alberta.

The last two aspects of the program look at the social and economic effects. As I said earlier, the studies we have done to date have been relatively simplistic and have been single variable estimates. What we have done is we have started looking at three areas within Canada and looking at them on an integrated basis. We have taken the three areas of Canada that seem at most risk from a change in climate: the Great Lakes basin, where the vast majority of Canadians reside and where most of our fresh water is located; the prairies, where our whole agricultural system is potentially vulnerable; and, lastly, the McKenzie basin, an area where not a large number of Canadians live but a very important area from an ecosystems perspective, and one that is quite vulnerable to a very small rise in sea level.

In terms of climate change detection, we are looking into past climates and are in fact doing some simulations based on a period of some six thousand years ago. That's being done collaboratively with colleagues in the Geological Survey of Canada. We are looking at temperature, precipitation trends, ice and snow cover trends. What I would like to do is give you a quick snapshot of the results coming out of a reference network that we have established in terms of temperature change. This is to show how dramatically different one winter can be from an average winter. We have thirty-years of normal winter and then the winter of 1992. In some regions of this country it was some seven to eight degrees warmer than the normal—very interesting pattern—and a very cold zone on the East Coast around Labrador and Newfoundland. In my opinion, this is not a climate change as a result of the greenhouse effect. I think it is a very dramatic example of the El Niño effect. We have also looked at the temperature patterns within Canada over the hundred years that we have had a network of some three thousand stations for recording climate in Canada. I would have said 90 or 95 per cent of them were quite irrelevant from a detection of trend perspective. Many had moved the location where they had done readings from downtown to an airport. We had the longest record, which is currently sitting at the corner of Bloor and Yonge streets in downtown Toronto. It has given us a tremendous climatic change—something like three to four degrees over the period. I would not claim that this is anything other than urbanization. But we went through our records and boiled it down to a hundred and thirty stations that we feel we have some degree of confidence in. That shows a trend of about one degree. Interestingly, if you break that down by region, you will see that the warming within Canada is in fact occurring in basically the McKenzie basin area, the part of northern Canada where we are seeing temperature increases of about 1.7 degrees over the same period. When you look at Atlantic Canada you really see very little change.

This program of reducing uncertainties is very much a partnership program. It is a program that cannot be done by one government lab. It has to involve all of the scientific community in Canada that is willing to participate. We have the concept of a climate research network which is being developed and I would anticipate within the next few months the identification of ten principal investigators to do research into various aspects. The majority of those principal investigators are going to be located in universities. We are encouraging all levels of government to be involved and the private sector. One of the concepts we have, and this is a little bit of a promo, is the concept of a Canadian centre for climate that would act to integrate this activity and act as the focal point. The expectation is that the centre would be a non-government, non-profit organization.

The bottom line for all of this? I like to use the quote by Neil Armstrong from his visit to the moon back in 1969. His comment was: "When you look at the earth from a lunar distance, its atmosphere is just observable, so thin, a small invaluable resource. We are going to have to face the fact that we have to learn how to conserve it and use it wisely." That was some twenty-four years ago. A very key concept in my mind.

## General Discussion 2

**Lawrence Mysak:** I have some comments and questions pertaining to nearly all of the talks about resilience, about uncertainties, about surprises of the future and about climate studies, both of the modelling nature and of another nature. I think it's all stimulated by the really exciting discovery of the recent ice core that has just been taken of the Greenland Ice Cap which shows that the last warm period, the last interglacial, a hundred and twenty, thirty thousand years ago, was very different to the present warm period, the last ten thousand years of which has been very stable relatively speaking, with one or two degree global changes. If we can believe the ice core results, and I understand there is some dispute about them but given that they are correct, the changes are of the order of plus or minus five degrees. So talk about adaptation because these changes are believed to have occurred on very short time scales, over decades, not over hundreds of years. So there's that question of adaptation, the question of surprise, the question of adaptation which was slightly alluded to in Dr. Dawson's presentation. Probably the most important aspect which can explain these rapid changes is the subsurface ocean circulation which transports as much heat as the atmospheres, is known to respond in time scales of decades, and which can go into an entirely different state, a different equilibrium which is a very, very different climate. Therefore the whole question of natural climate variables is just as important as the climate change issue, but was not discussed at all.

Finally, this relates to the speaker on ecological survey satellite observations, namely that the problem with the subsurface ocean circulation is that it is a subsurface phenomenon and you cannot easily detect it. But we do know that it has a very intimate link with the fresh water flux throughout the globe, and I think that it is a real challenge for the satellite community to get a better handle on water fluxes and also on the surface of the ocean.

**Kirk Dawson:** Your comment is absolutely no surprise Lawrence. With the whole question of surprise (I have an overhead which I didn't use here) the only thing I am certain on is that we have got it wrong to some degree. We will be surprised. That, I think, is the key aspect of this. I agree wholeheartedly with him, in that we apply only the physics of linearity in this work to date, and certainly the ice cores do not seem to exhibit that same degree of linearity. They do seem to indicate multiple stable situations with very short periods of stability, and I remember about five years ago being updated with comments to the effect that if you look at the upper air data in some degree of detail, it seems to indicate that we have had two stable states within the past seventy years. So I would agree with that. It does argue that we need to pay far more attention to the whole question of adaptation, of improving the resilience of our systems to surprise. That is an area where I really seek the help of others, because its an argument that I have been totally unable to carry to decision makers in an effective manner.

**Alan Davenport:** I wanted to ask about the other side of climate change, which is the fluctuations in climate. It seems to me that much of the impact of climate change is going to be felt through extremes such as the extremely bad winter of 1992, and I wonder if there is any comment on work that can be done on that area.

**Kirk Dawson:** There is certainly a considerable amount of interest in that question. I don't know if there is any scientific consensus other than that of the Intergovernmental Panel on Climate Change. That is, you really don't expect any significant change in the variability of the system. That, I think, was the conclusion of the IPCC. There are a number of people who would disagree with that conclusion. There are a number of people who said that it might be true on the average but since the climatic system will have different regions, a given location may experience a significantly different series of extremes than what it has experienced in the past, without the whole system being significantly more extreme.

The insurance industry would really like to know whether there is in fact a change in the extreme events. There was a very interesting workshop in the Netherlands about three or four months ago that was addressing that question, and I think that the bottom line conclusion was that it was a hung jury, that there were some who thought it would be more extreme and others who did not. There's a lot of work going on to address that question. Time will tell.

**Ian Rowe:** I am the Executive Director of one of the co-sponsors of this event, the Institute for Space and Terrestrial Science. Dr. Takagi made an interesting suggestion that I don't think should pass us by. That idea is for a system for storing and processing data, data that is really required by centres all around the world. He suggested it could be the basis for a project between Japan and Canada. I think that is something that we should perhaps explore not necessarily at the moment, but I didn't want to let it pass because I wanted to make him aware, and this group too, of some interesting work that has being going on at the Institute for Space and Terrestrial Science which would make a significant contribution to that project. I also wanted to make him aware of some technology that has been developed by one of the participants in the Freedom Canadian Space Station Program. It is software that lends itself very nicely to a user-friendly and seamless interface. The technology developed at the institute significantly brings down the cost and accessibility of mass storage. So when you bring those two together, along with the architecture that you have set out for us, I believe that together we could put together the basis for a database, the cost of which would be significantly reduced using some of the technology that I have just described. So I would be delighted to pursue that with you but we really need to have the scientific community decide that this is an imperative and is worth pursuing. So I will lob the question back to you and some of our other colleagues. We can help. We can make a significant contribution. We would be delighted to work together.

**Mikio Takagi:** Thank you for your comment. I think we need a new concept, and I also know in Canada the advanced technology for remote sensing is very strong so I think we can exchange information and also I think you are very good in software and Japanese hardware is very good. So I think the advance of techniques in this field from both sides solves global problems and so I think we can establish good cooperation. Thank you.

**Kirk Dawson:** I was going to comment that I think this need to maintain perpetually a significant amount of the data we collect is in fact an absolute requirement. Unfortunately I see us moving in the opposite direction at this stage. We are actually throwing more data away than I think we are retaining. I think one of the reasons that we are able to actually go back and mine the climate data of Canada is because people collected it and managed it for a period. Not only did they manage the data but they managed the data about the data which is probably even more important than the actual data itself. If you go back and look at the trend analyses and you see a sudden change, a sudden jump, you want to go back and say was that a real change or was it an artifact of the observing system? In most cases when we go back, we find it was an artifact of the observing system. A tree grew up, or somebody moved the screen around so they could get a better exposure. Those are some of the things that have happened. We tend not to manage that data as effectively, so I would be arguing not only to manage the data but to manage the data about how we collected it—what were the sensors, how did we calibrate them etc, etc. I think in about thirty years time we may be able to analyze some of the trend data coming from satellites. I don't think we can do that now.

**Gordon McBean:** I'm with the World Climate Research Program. I just wanted to make a couple of comments and then make a suggestion. One is that it has been rather interesting to see the evaluation of climate science, particularly over the last few years, and how the emphasis has shifted from early on in the eighties when we started these kinds of activities as somewhat of an academic exercise, then there was the thrust to understand climate change due to the greenhouse effect. But now, in the last few years, there has been much more interest again in questions of natural variability, and the comments of Lawrence Mysak and Alan Davenport on the question of how the variations in the climate system (much of which is natural we think at this stage anyway) will influence human activities and ecosystems.

Anyway, in particular I want to ask a question concerning space sensors. One of our concerns in climate research has been the need for international coordination amongst the various space agencies—the Japan Space Agency, NASA in the U.S., the Europeans, the Canadians, etc.—working together, particularly in the area of what I would call active sensors. Lawrence Mysak quite correctly noted that we can't see below the surface, but we could see the atmosphere a lot better if we were to go into things. For example, if we wanted to know the atmospheric transport of water better, we really need to know the winds better. In space, we would like very much to see cloud radar in space and these kinds of things, and it seems to me the only way that this is going to happen is if the space agencies and the science community work together to identify ways in which we can co-operate, rather than everyone individually building orbiting satellites or whatever other proposals are on the stage now. I would like to hear a response from either the speakers or others as to how we might try and make this work in a more effective way on an international scale. Thank you.

**Kirk Dawson:** I will make one comment Gordon, and probably no surprise too. I think the solution in my mind is in the development of an effective world climate program that identifies all of the activities in a coordinated manner. It then could be presented effectively to countries to undertake the necessary commitments of the right equipment, the right sensors. I think that an integrated program is vital if we want to get the type of balanced response from the providers, if I may use that word, that we actually need. I think you are in an ideal position to influence that yourself.

**[Unidentified speaker]:** I am a little surprised that there has been no mention, or very little mention of the contribution to greenhouse gases and to particulates in the atmosphere by volcanic activity. Now we all know that the Mount Pinatubo occurrence was a surprise, and an example of adapting to surprises. It effected the climate. It literally blew all the theories of global warning off the map and changed the climate of the last couple of years substantially, and I am a little surprised that there doesn't seem to be any national or international program on the monitoring of volcanoes which could be quite easily done from space, monitoring the particulates and the contribution of the volcanic ash of the volcanoes to the greenhouse gases. If the record had been properly kept over the years, it's possible that it could be shown that the volcanoes had contributed to greenhouse gases more than anthropological changes. I am wondering if you have any comment on why more attention is not being paid to volcanic output.

**Kirk Dawson:** Yes. I think that I will take exception to one part of your intervention and that was that Pinatubo blew global warming theories off the map. I don't think that is true at all. I think its occurrence enabled a number of members of the climate community to in fact predict what the likely influence of that event was going to be. I think they have shown that their understanding of the system was able to carry out that prediction quite effectively. It clearly was an effect of about half of a degree cooling for a short period of time. Short in climatic perspectives being one or two years. There is no doubt that it gave rise to an absolutely miserable summer here in Eastern Canada last year. For those of you who lived here it was not a pleasant time. We are now seeing a "back to normality," if the climate system can ever be defined as normal. I think there is awareness of the role the volcanoes do play. There is, I think, an increasing interest in being able to include some of the subsidiary effects of volcanic activity into our models of the atmosphere. Our models to date have been relatively simplistic. They have been well-mixed gases. Clearly the situation involving a volcano is not a well-mixed gas. We need to do a lot more work there. I think the issue is an active issue. I think it is one of the many parameters, one of the many forcing agents that we have to pay attention to.

**Elaine Wheaton:** Elaine Wheaton of the Saskatchewan Research Council, Adjunct Professor with the University of Saskatchewan. I just want to address the concept of adaptability and say that yes we do need to address the question of how to promote the benefits of adaptability. As Dr. Robinson pointed out this morning, it's a type of set of actions that will really help prepare us and improve our sustainability. We do also need to concentrate on international co-operation and I would like to hear your comments about how to do that. Thanks.

**Kirk Dawson**: Help me.

**Elaine Wheaton:** Perhaps as well as working with policy and decision makers, we should also be working with the decision-makers at the community level and with corporations. I think that would help.

**Kirk Dawson:** I think that would be a very useful activity. I get an impression that one of the reasons for some caution in terms of accepting the idea of improving resilience and the need to adapt is an admission that if you do that you are going to admit that global warming or climate change is in fact a reality. It may be easier to reject the basic hypotheses and then you don't have to deal with it. That is a very cynical view but sometimes I tend to get cynical.

**Gary Lindburgh:** Gary Lindburgh from the Canadian Space Agency. I just thought I would bring a couple of bits of information forward. There is an increasing amount of coordination taking place between space agencies and in particular I want to call to your attention to a wonderful committee called CEOS, the Canadian Earth Observing Systems, which has memberships from NASA, NOA, Japan, ESA, Russia, China, India, and Brazil. The principal set of objectives of CEOS is to try on a world-wide basis to coordinate satellite systems in the earth observing field to attempt to avoid duplication of sensors and to attempt to address needs.

We are doing two or three very important things. One is promulgating data policy—talking about the access to data for global change research. Looking very hard at and very actively at data standards and standard formats so that if someone does produce data, it's a standard format you can access into a network. We are also pushing very hard on collaboration and validation because you need to know what it is you are measuring.

One other thing I would like to point out is in addition to those space agencies we have a large number of affiliate members, and we are challenging our users to in fact get together and tell us first off what their requirements are, not on an individual international organization basis but rather on a coordinated basis with some priorities. So we are trying to organize ourselves to respond to user requirements rather than building the instruments that we know we can build, and we are also challenging the user community to come up with a coordinated set of priority requirements. So I think there is some hope even though as you well know, international organizations, be they users or be they data providers, are very ponderous. Thank you.

**David Fisher:** David Fisher, Geological Survey of Canada. I would just like to report that we have an active program going on with the Japanese in studying ice cores, which is our specialty with the survey. We have been doing this for three years new and we are planning to continue it in further years. This includes scientists from Canada going to Japan and Japanese glaciologists and ice core people coming to Canada and participating in the ice coring activities, drilling and analysis. So this is an ongoing, existing program and will be continuing into the future.

I would like to point out an interesting contradiction. I have been keeping a running total of how many people have spoken and asked questions. I have noticed that seven people have pointed out how unpredictable the future is going to be both in terms of technological and scientific breakthroughs that make scenario planning difficult, and also the intransigence of unpredictability of climate changes the ice core people are suggesting and the natural variability of climate. So it seems that unpredictability in the technology, the climate and environment in general is generally agreed upon—and these people come from government, industry and academia. But as a line scientist one thing I find more and more and more is that most people in the business are lumbered with the concept of strategic planning and sector research. Now uncertainty and this procedure don't go together. I point that contradiction out when I have so many decision-makers in the room here. Thanks very much.

**John Robinson:** Just on this issue of adaptability I have been puzzling over what you were saying, Kirk, about unwillingness to listen and I don't know if this helps or hurts. It's useful, I think, to recognize that in at least two ways adaptability and mitigation blur, and it's not sensible to separate them. One, there are a lot of mitigation measures that increase adaptability. Energy efficiency, for example, done in order to reduce greenhouse gas emissions, typically makes the system more resilient to unexpected change—not always, but often. And so sometimes you can get a double bang for your buck and maybe that will sell. If mitigation can be sold, maybe adaptation can be sold because it can help mitigation or *vice versa*.

The other, more fundamental thing, is that in the long term there isn't any such thing as non-adaptation, so the idea is again, back to this business-as-usual. If you have business-as-usual and everything else is adaptation, then almost by definition, and indeed by definition in terms of the microeconomic models which use everything that deviates from business-as-usual as higher cost, adaptation means higher costs and is customarily seen that way. But if you step back from that and then you say what we have is different configurations, they are all adaptive in one way or another and they are adaptive to different things than climate and that may be the key. No regrets (or worth doing anyway, as we prefer to call it) we use as a way of selling mitigation for reasons other than climate. I think adaptation has to be sold on that basis too. What we have to do is adopt strategies that are resilient not just because of climate change but *also* because of climate change. For example, a scenario I presented this morning results in a sixty percent reduction in greenhouse gas emissions by 2030. That just happens to be the IPCC lower limit for stabilizing atmosphere concentrations. That wasn't a goal of the study, but for reasons other than that we end up with that kind of outcome. I think adaption has to be sold both tied with mitigation tightly but secondly and beyond climate change, in order to benefit from all the other kinds of arguments around.

# 3. Science and Technology for the Global Environment

Chairperson: Dr. Ellsworth LeDrew, Director, Earth Observations Laboratory, University of Waterloo, and the Institute for Space and Terrestrial Science

## Japanese Policy on Science and Technology for the Global Environment

Mr. Masahiro Kawasaki
Executive Director, Research and Development Corp. of Japan; Former Director General, National Institute of Science and Technology Policies

### Introduction

Around the world today, concern is growing that in the near future on-going changes in the global environment may threaten the life of the earth. Increasingly, the general understanding is that it is essential for nations to take immediate and effective countermeasures to preserve the global environment, and, in parallel, to promote more intensive scientific research and observation in order to define the nature and the extent of the problems.

In the 1960s and the 1970s, Japan and other advanced countries experienced serious environmental problems. They have been overcome with a combination of regulations for emission control of pollutants and technology development for waste management by governments and industries. However, nature and aspects of today's global environment issues are changing from the previous ones. That is to say, the present state of the global environment is changing from looking at a single kind of pollution caused by a specific pollutant, to a more complex model. The impacts are changing from a limited local area and country to the global, beyond national borders. Listed as major causes are not only industrialization, urbanization and motorization, but also natural phenomena and human behaviour as a whole.

In order to understand the present and future problems of the global environment and to find out necessary countermeasures, it is essential that each nation promote its own scientific research and development of technology for the conservation of the global environment as well as international cooperation for this purpose.

This paper discusses the current state of Japanese science and technology policy in the framework of overall global environment policy.

### The Administrative Structure for the Global Environment and Science and Technology

In Japan, the central administrative structure for the environment and science and technology is shown in Figure 1. Although these structures are interdependent, the main function is expected to be to coordinate various authorities' activities in each policy field.

Today's global environment issues are not covered by a single policy area, but require the concerted actions of the wide-range policy areas. From this point, the Cabinet decided to hold the Ministerial Conference for the Conservation of the Global Environment in May 1989.

For science and technology policy, the Council for Science and Technology (CST) was established under the Law in 1959 as the highest advisory body to the Prime Minister. In fact, the CST plays a significant role in coordination, because various ministries conduct their own science and technology activities for their policy objectives. Particularly, the coordination of universities and other ministries' activities is expected.

In addition, the Council for Geosciences (Sokuchigaku-Shingikai) has been working as an academic advisory body to the Minister of Education, Science and Culture that is composed of scientists in respective fields.

Science and technology policy for the global environment is treated by both administrative organizations in Japan.

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                     ┌-- Min. of Foreign Affairs ---┐
                     |-- Minister of Finance ------|
                     |-- Minister of Education, ---|
                     |   Science & Culture (MOE)   |
                     |-- Min. of Health & Welfare -|
                     |-- Minister of Agriculture, --|   Council for
Ministerial          |   Forestry & Fisheries      |   Science and
Conference for       |-- Min. of International -----|   Technology
the Global           |   Trade and Industry        |
Environment          |-- Min. of Transportation-----|      Chairman:
                     |-- Minister of Post and ------|   Prime Minister
Chairman:            |   Telecommunication         |
Prime Minister       |-- Minister of Labor --------|      Secretariat:
                     |-- Minister of Construction---|     STA amd MOE
                     |-- Minister of Home Affairs --|
Secretariat:         |-- Min. for Hokkaido Develop.-|
Environment Agency   |-- Min. for Economic Planning-|
                     |-- Minister for Science and---|
                     |   Technology (STA)          |
                     |-- Minister for Environment -|
                     |-- Min. for Okinawa Develop. -|
                     |-- Min. for National Land-----|
                     |-- Secretary General of ------|
                     |   the Cabinet               |
                     |   Chairman of Science -------|
                     |   Council of Japan          |
                     |   5 Men of Learning and     |
                     |   Experience                |
                     └   (Liberal Democratic Party) ┘

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        Note: 1.     "---" means the regular member.
              2.     "---" means a minister may participate, if desired.
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**Figure 1.** Administrative Structure for the Global Environment and Science and Technology

## Science and Technology Issues in the Framework of Global Environmental Policy

In order to guide governmental policy actions, the Ministerial Conference decided "the Principles of the Overall Policy for the Conservation of the Global Environment" in June 1989, which are summarized in the following:

1. Participating to build up international schemes for the conservation of the global environment, Japan will take necessary policy measures from the global viewpoint.

2. Japan will promote its own research, observation and monitoring of the global environment in order to contribute to the scientific base of global environment problems. Particularly aiming at the international observation and monitoring network, Japan will promote observation of the atmosphere, ocean and biosphere including the monitoring of the global environment by satellites, and will also promote international joint research .

3. Japan will endeavour to develop and diffuse technologies contributing to the conservation of the global environment and participate in relevant international programs.

4. Japan will contribute to the conservation of the environment in developing countries by means of an increase in the ODA for the protection of the environment, by the development and transfer of technology appropriate to the situations of those countries and by the promotion of training

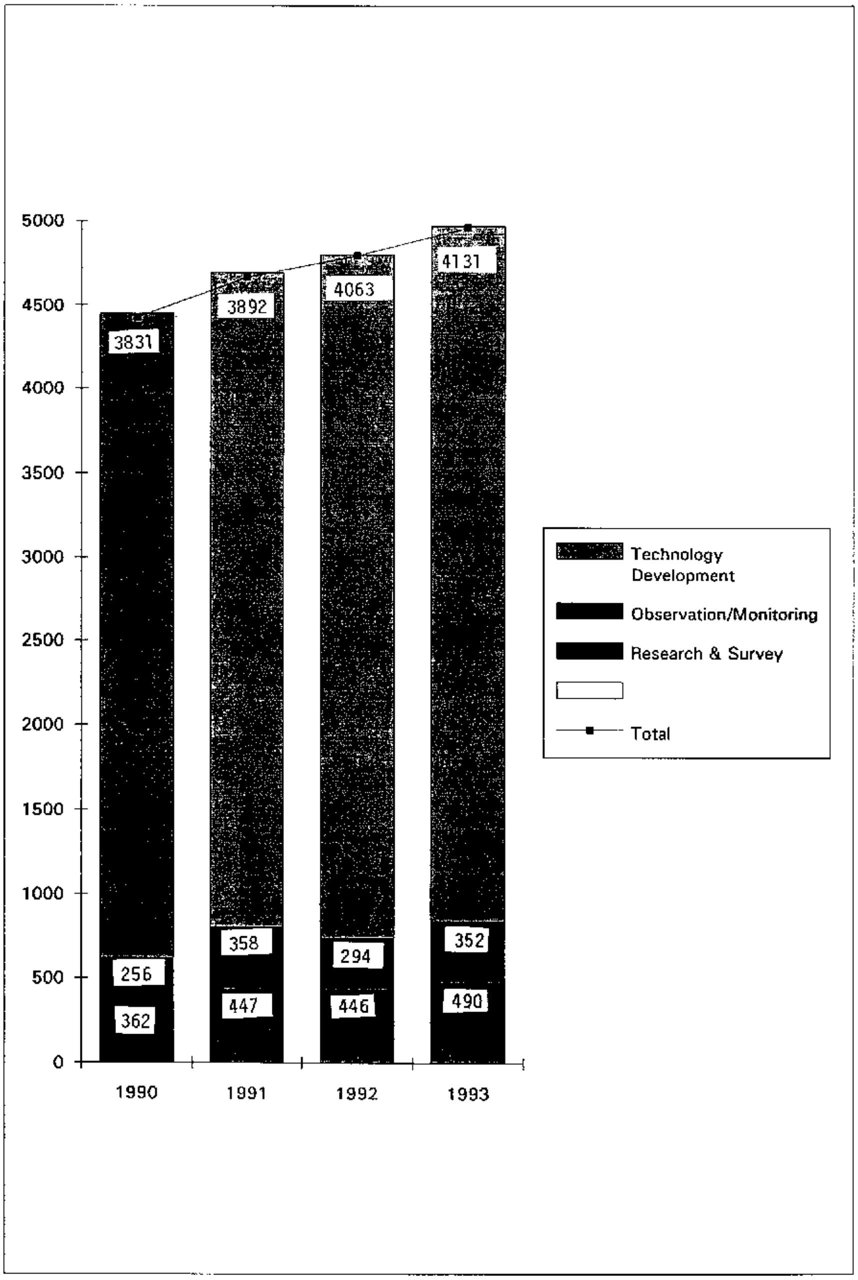



**Table 1.** The budget of the plans by purposes (in $M = 100Myen).

*Source: The Integrated Plan of 1991 and 1993 (in Japanese).*

for manpower needed in this field.

5. Japan will stress environmental consideration in the implementation of ODA projects. For this purpose, the Government will promote the formulation of procedures, guidelines and an execution system, as well as the training of manpower for the environment consideration.

6. Japan will endeavour to maintain economic and social activities in such a way that they have less impact on the environment through the promotion of resource and energy conservation.

Items two, three and six of the principles are directed at science and technology activities. In order to coordinate and promote those activities, the Ministerial Conference made a decision on the "Integrated Plan for Promotion of Research, Observation and Monitoring on the Global Environment" in October of 1989. The decision said: "In order to promote synthetically research, observation and monitoring as well as the development of technology for the conservation of the global environment, the Ministerial Conference will formulate an annual integrated plan of those activities at the beginning of every fiscal year, and shall be annually informed of the progress of that plan."

This decision has a significant meaning in that the processes of forming the integrated plan result in effective promotion of those scientific and technological activities conducted by different ministries in a coordinated manner, and often in a rivalry.

As the budget of the Action Plan shows in Table 1, the annual increase rate of this budget remains at 5 to 3 per cent, which is relatively higher than the national total budget, which is in a serious financial situation. As regards the contents, roughly two thirds of the budget of "Observation and Monitoring" covers the research and development (R&D) cost of earth observation and meteorological satellites, and the cost of energy-related R&D, including nuclear energy R&D, shares the largest portion of the total budget of "Technology Development".

The ministerial distribution of this budget is shown in Table 2.

Nine tenths of STA's budget is allocated to nuclear energy R&D and the rest is mainly for development of the earth observation satellites. One fifth of MITI's budget is allocated to new energy R&D, including nuclear energy. The share of budget for scientific research on the global environment, in a narrow sense, is relatively small.

This budget also covers "the Action Program for the Prevention of Global Greenhouse Effects," that was decided by the Ministerial Conferences in October 1990. The Action Program states that:

1. the program covers the period from 1991 to 2010, and the interim target year is the year 2000;
2. the per capita emission amount of $CO_2$ after the year 2000 shall be kept almost at the level of the year 1990;
3. the total amount of $CO_2$ emission after the year 2000 shall be stabilized at the level of 1990, in anticipation of remarkable progress in the development of technology, such as solar and hydrogen energy, fixation of $CO_2$ etc.; and
4. the emission level of methane will not exceed the present level and the emission of other gases causing greenhouse effects, such as nitrous oxide, etc. will not increase.

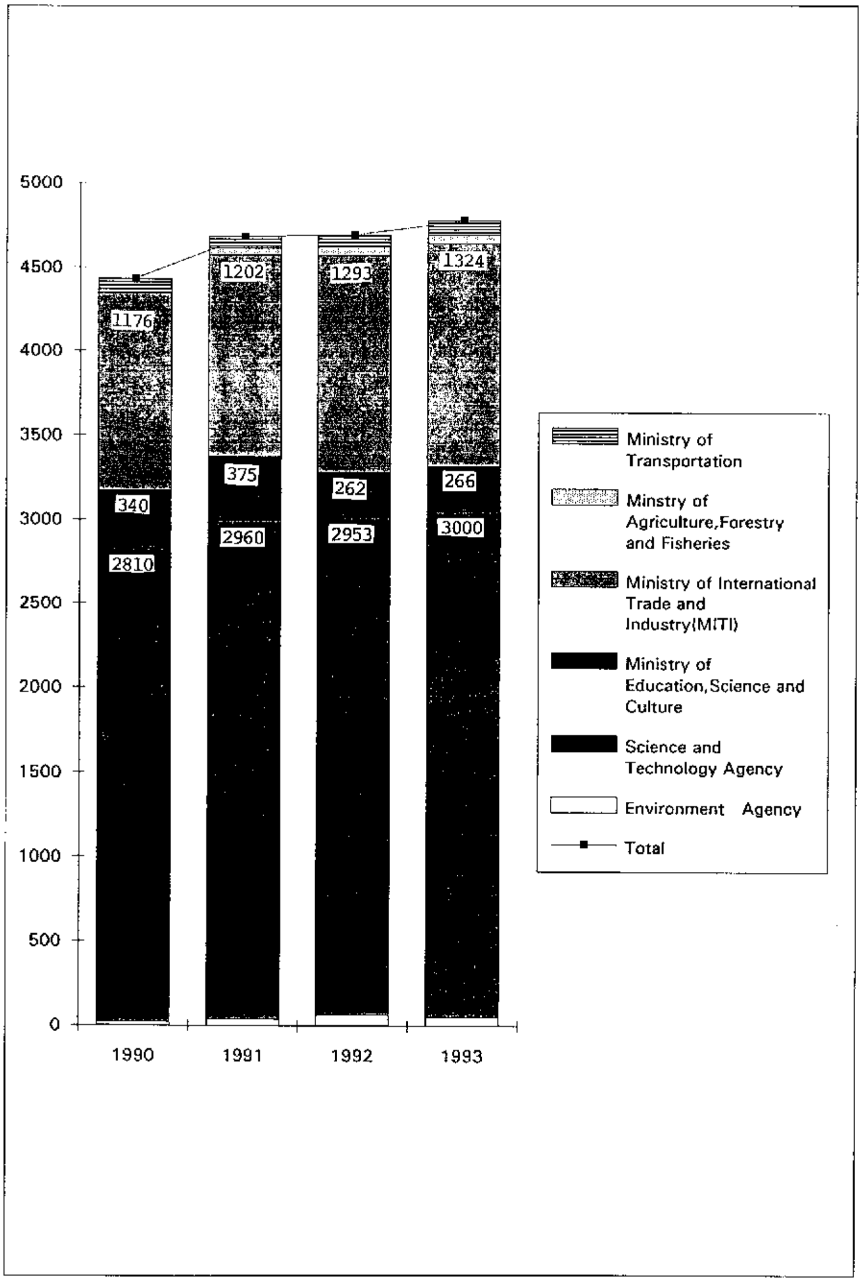



**Table 2.** The budget for the global environment by major ministries (in \$M = 100M yen).

*Sources:*

*1. Environment Agency "Kankyou Hakusho" in 1990 (White Paper on the Environment 1990).*

*2. "The Integrated Plan for the Promotion of Research and Development on the Global Environment, May, 1993" (Japanese version only).*

## Action of the Council for Science and Technology

In June 1990, the Council for Science and Technology (CST) recommended to the Prime Minister "The Basic Plan for R&D on Geosciences and Technology," in response to a request from the Prime

Minister, made in March 1989. The discussion of this recommendation reflected justly the Principles, the Integrated Plan and also the Action Program mentioned above. The priority of R&D activities are defined by this Basic Plan as follows:

1. The increase of scientific knowledge on the earth and of various phenomena on the earth.

2. The forecasting and predicting of various natural phenomena on earth, such as global climate change, earth-quakes, volcanic activities, etc. on the basis of scientific knowledge provided by activities of number one, above.

3. Science and technology for the continuous development of human society, such as surveys of natural resources, utilization of natural energy.

4. Science and technology for the prevention of greenhouse effects and the conservation of the global environment.

5. Common and basic technologies for observation and information systems.

The Basic Plan also stressed that:

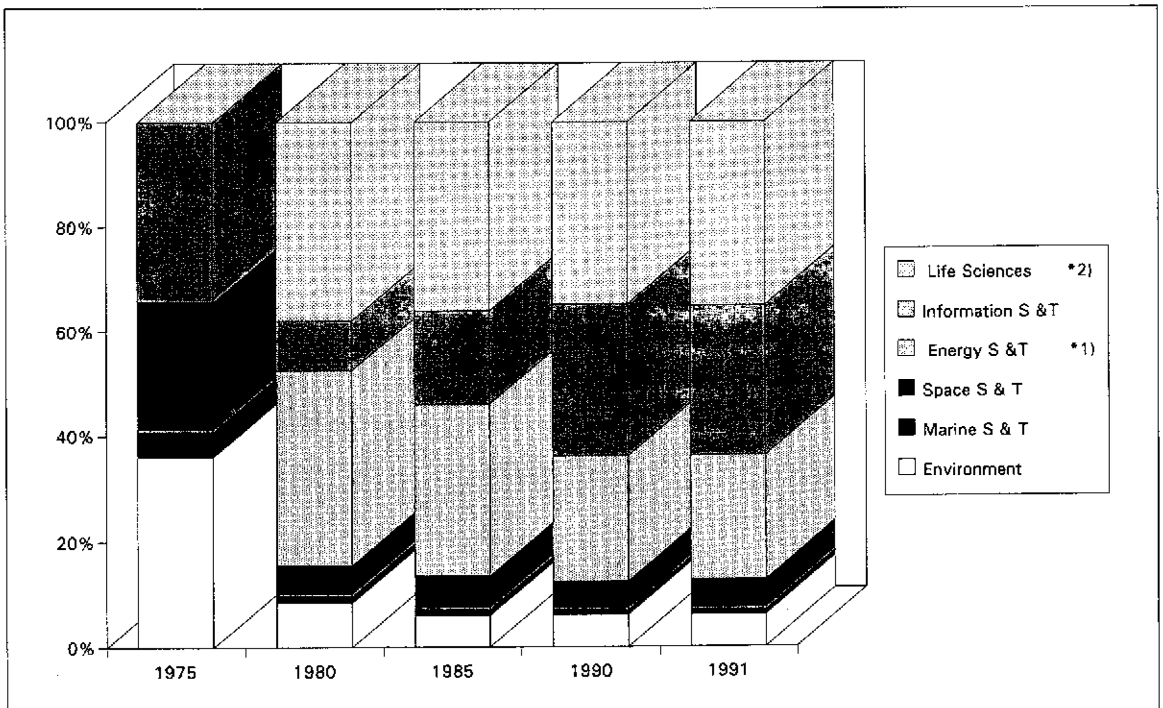
1. any R&D in these fields shall be promoted by synthetic approaches and with macro and long-range scope;

2. cooperation among universities, national laboratories and industries shall be promoted;

3. international cooperation in scientific research shall be promoted with respect to geographical location as well as relevance to the science and technology of Japan;

4. the government shall promote education and training of talent in these fields; and that

**Table 3.** R&D expenditure by major purposes. Japanese R&D expenditures are concentrated in the fields of life sciences (11.5%), information science and technology (9.4%) and on energy (7.7%).



5. the government shall make efforts to provide funds necessary for R&D, for building up the observation and information system, for instrumentation and for the international exchange of researchers.

As regards international cooperation, the Basic Plan proposed that Japan will promote research in the geosciences, focusing on the Asian and the Western Pacific Ocean zone, and that Japan will

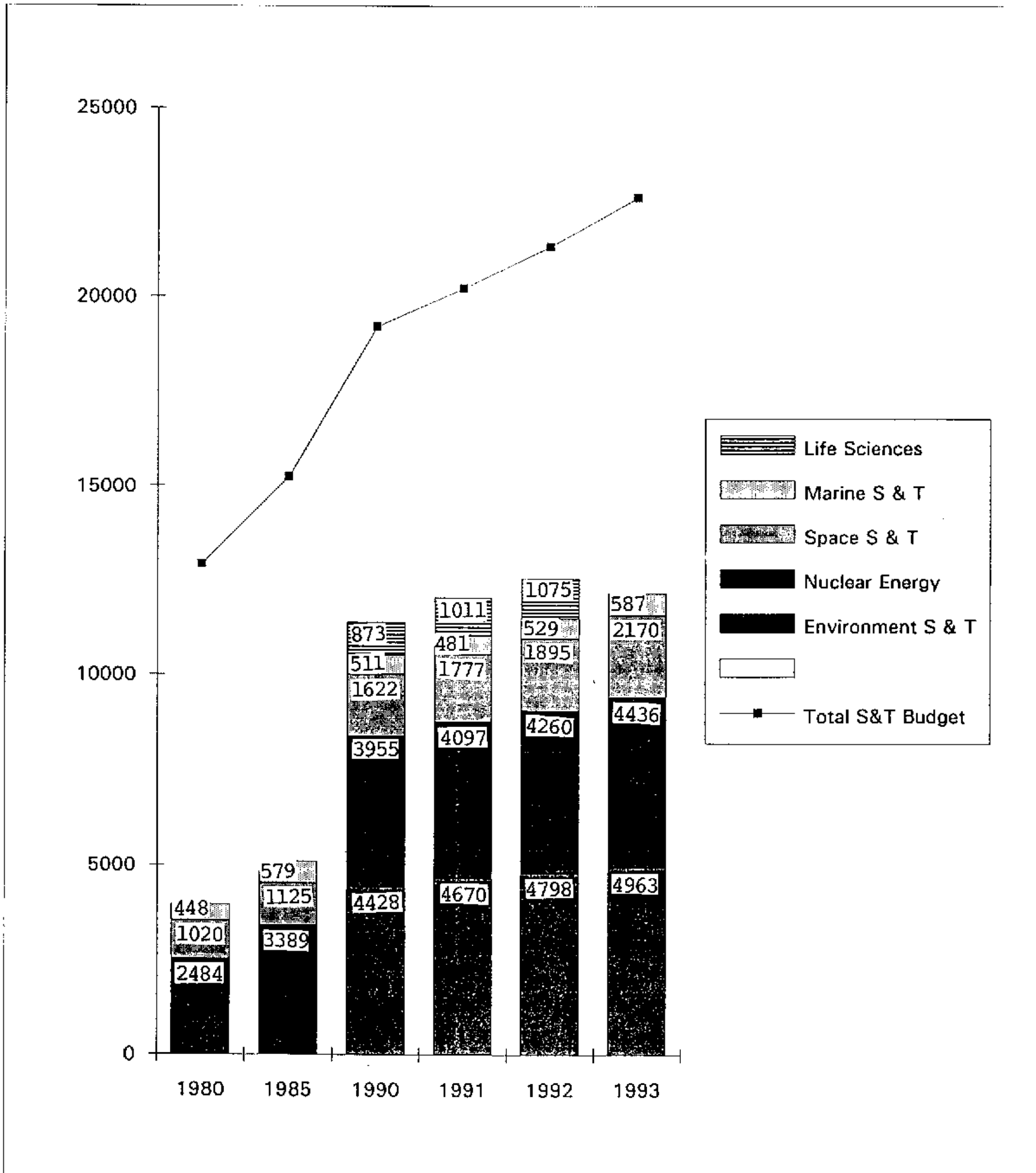
**Table 4.** The science and technology budget by purposes.

*Sources:*

*1. "The Budget for Science and Technology" (1993), Science and Technology Agency, S&T Policy Bureau.*

*2. "The Integrated Plan for the Global Environment" (1991 and 1993), Environment Agency.*

*3. "Science and Technology Indicators" (1992), STA.*



participate in international joint research such as IGBP, WCRP, ODP, STEP, etc. This Basic Plan is almost consistent with the Integrated Plan decided by the Ministerial Conference, except that nuclear energy R&D is covered by the Ministerial Conference. Therefore, both Plans are playing a guiding role in science and technology activities conducted by each ministry in Japan.

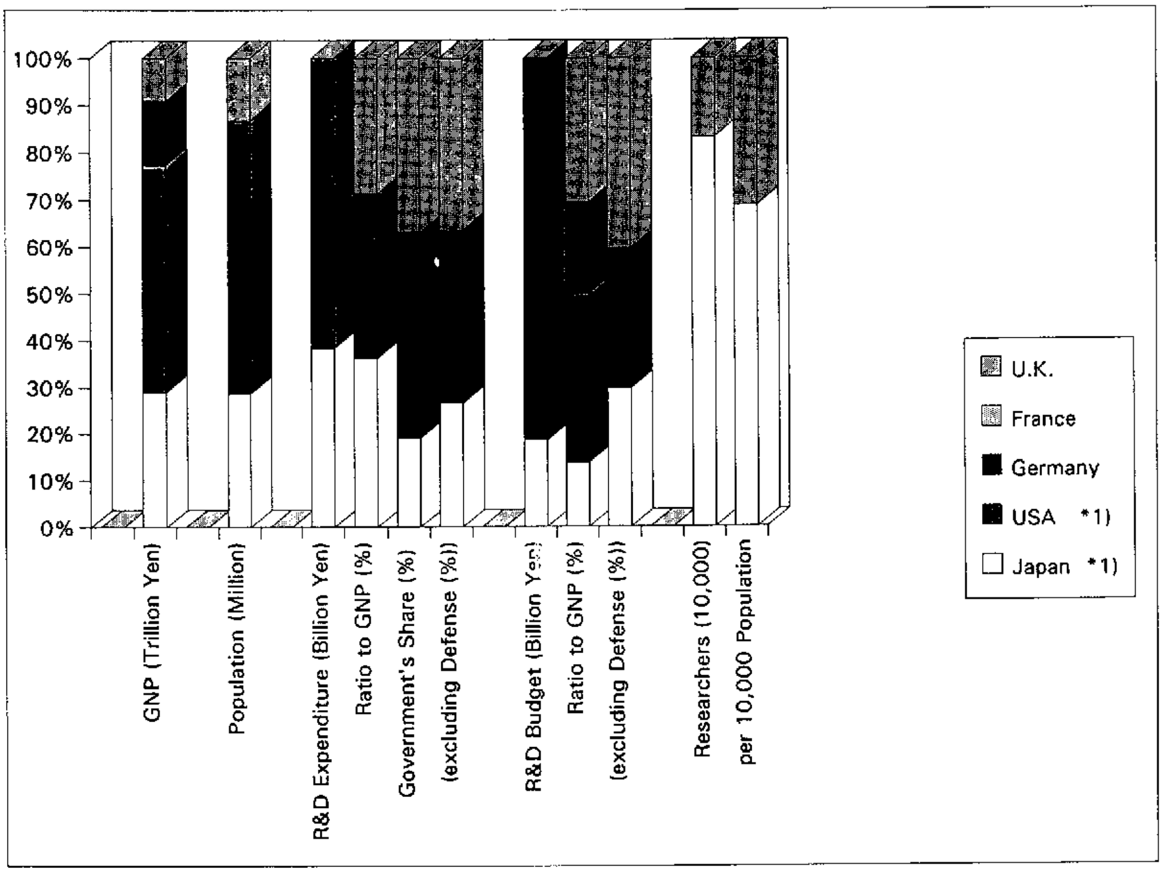
## The Current State of R&D Activities for the Environment

At present, Japan is promoting science and technology activities for the conservation of the global environment, pursuant to the Basic Plan of the CST and also the Integrated Plan decided by the Ministerial Conference.

According to the statistics on Japanese overall R&D expenditures, R&D for the global environment was estimated at almost 2% of the national total R&D expenditure in 1991. Table 3 shows R&D expenditure by major R&D purposes. In Japan, more than half of the R&D on the environment has been conducted by industry, and total R&D expenditures are less than the budget mentioned above (Table 1) because some items included in Table 1 are categorized into space S&T and energy S&T in Table 3.

On the other hand, the governmental budget for science and technology are concentrated in global environment (21.9%) and nuclear energy R&D (19.6%). However, it must be considered that both some part of energy R&D and R&D on earth observation satellites are accounted for in the global environment R&D budget as explained in Table 1. Table 4 shows the distribution of the governmental budget for science and technology (environment R&D budget is the same in Table 1 and also some

**Table 5.** R&D Structure in major countries (1990).



items are double-accounted in the different fields).

## Conclusion

As mentioned above, the Japanese government is facing the challenge of global environment issues not only at the social and economic level, but also at the science and technology policy level. However, it seems that during the actual implementation of policy, particularly with science and technology policy, the Government faces big problems as regards how much public funding to allocate to global environment issues among several priority fields of science and technology, and how to keep finance policy sound. These questions are the same for general science and technology policy.

Table 5 shows the size of R&D capacity and the features of R&D structure of major countries. The structural issues of R&D in Japan are summarized as follows:

1. Industry is a major player in overall R&D financing.
2. The share of the governmental R&D funds is decreasing every year.
3. The universities' share is going down relative to basic research.
4. International academic activities are not enough, particularly, the contribution of papers to international academic journals.

Reflecting these situations, the Cabinet decided on Policy Guidelines of Science and Technology in March 1992, based on the recommendation of the CST. In these guidelines, science and technology policy goals are defined as: 1. the magnification of scientific knowledge and 2. the building of a safe and comfortable society. The following policy priorities were also settled:

1. promotion of science and technology for the improvement of living conditions and welfare,
2. establishment of "Centers of Excellence",
3. strengthening international activities, and
4. the promotion of science and technology for regional development.

In order to attain these objectives, the budget for science and technology shall be increased to twice as much as the present one, as soon as possible.

Pursuant to these guidelines, it is strongly expected that the budget for promotion of domestic and international science and technology activities for the global environment will be affected.

# The Future of the Global Environment: Canadian S&T Policy

*Alan Nymark*
*Assistant Deputy Minister, Policy, Industry and Science Canada*

It is a pleasure to be here today to speak to such a distinguished and diverse group. The subject of this Symposium, *The Future of the Global Environment*, is a critical one, and one that is important to us all. I am here today representing Industry and Science Canada. ISC, as we call it, is a new department, created in the recent restructuring of federal departments. It was created from Industry, Science and Technology Canada, the telecommunications programs and policies from the Department of Communications, the marketplace and business framework responsibilities of Consumer and Corporate Affairs Canada and the investment research, policy and review functions of Investment Canada. Our mandate is to foster business development, efficient markets, and Canadian competitiveness by:

- integrating many of the key levers of micro-economic policy;
- providing strategic information and analysis to business;
- improving business access to government;
- reducing internal barriers to trade; and
- managing federal science and technology (S&T) expenditures more strategically.

In the new economy, knowledge and ideas have become the most important factor of production—a source of innovation and the engine of economic growth. Innovation has become the core of this economy, encompassing both new technologies and the development of new organizations and new ways of doing things. We recognize that for Canada to succeed in this new environment, we must organize ourselves as a learning society.

Science and technology have been the drivers behind the creation of the knowledge economy, providing us with the tools for our continued prosperity. The technologies that provided the basis of the strong economic growth of industrialized economies for 35 years after World War II are becoming obsolete and are being replaced by a new set of technologies. The new technologies are creating new industries, new products and even new economic and social institutions. They have changed the basis for creating competitive advantages.

Another impact of the new technologies is that they have radically improved communications and helped bring about the interdependence of national economies into an increasingly unified global system. Competition is no longer a domestic affair—businesses are competing against their counterparts in every corner of the world.

At the same time that the economy is becoming globalized, we are all starting to take more responsibility for the impact that the global economy has on the global environment. Science and technology can provide some of the important tools needed to achieve the goal of a prosperous world economy in a healthy global environment.

The Government of Canada's policies for science and technology are designed to support an economy based upon innovation. The objectives are:

- to build industrial capabilities in the technologies essential for maintaining a competitive position;
- accelerate the diffusion of best practice technologies;
- use the government's own science and technology infrastructure to transfer technology to the private sector;
- assure a strong university research infrastructure and supply of qualified expertise; and
- address social issues such as health care and environmental protection.

Since about 1989, the government has been actively supporting industry pre-competitive R&D alliances in technology fields such as biotechnology, information technology and advanced materials. These alliances can have both domestic and international partners.

The Networks of Centres of Excellence Program supports leading-edge research and training in fields of longer term importance to Canada. It was launched in 1989 with a budget of $240 million over five years and was recently renewed for a second phase. The 15 Networks cover a variety of fields including chemical physics, genetic and bacterial diseases, insect biotechnology and cement. About 800 of Canada's top researchers, 1,320 graduate students, and 465 post-doctoral fellows participate in the Networks. Thirty-six universities are involved, along with 31 federal and provincial government facilities and over 140 companies.

The federal government invests about $6 billion annually in science and technology, about $4.5 billion of which supports its own laboratories and science and technology activities. Federal science-based departments and agencies operate about 200 laboratories, with more than 33,000 people, across the country. These laboratories are open for business, to collaborate with firms in joint projects. They also support the basic missions of government—regulations and standards, health and safety, and protection of the environment.

The deployment of best practice technologies is also a priority in Canada. The National Research Council maintains a large group of industrial technology advisors across Canada to assist small companies. They work in collaboration with other organizations such as the provincial research organizations and about 17 technology centres which are supported by my department.

Another example of the government's commitment to the infrastructure needed for an innovation-based economy is the decision to build a high speed, broadband network for the Advancement of Research, Industry and Education (CANARIE). This network will be managed by the private sector and be a test bed for the development of new information technologies. It will link universities, schools and industry to facilitate research collaboration and learning.

Canada's science and technology policy would not be complete without a focus on people. The federal government provides scholarships for science and engineering study in universities, as well as scholarships for studies in technology at community colleges. About 3,500 scholarships are provided annually.

It is also essential that young people and the public in general be aware of the importance of science and technology and work towards the development of an innovation culture. The federal government and the provinces have joined together to increase public awareness of science and technology through events such as National Science and Technology Week and promotional campaigns to encourage young people to consider science and technology as career paths. For example, scientists and engineers visit schools to discuss careers with students.

Science and technology are important not just to the health of Canada's economy. They are equally important to Canada's capability for *sustainable* development. Sustainable development is based on the premise that long-term economic growth depends on a healthy environment and a healthy environment is dependent on a prosperous economy. Mr. Kawasaki has given us a clear picture of how sustainable development is very much at the heart of Japan's vision of the future, and how science and technology can be key tools in realizing that vision.

Canada's Green Plan, about which you will undoubtedly be hearing much today, outlines our commitment to protecting our environment while at the same time promoting responsible development. In the same spirit as the Green Plan, federal departments and agencies now are obliged to include environmental concerns in all their decision-making processes.

Industry is being challenged to minimize environmental degradation by making its operations and products more efficient and friendly towards the environment. As a result, the S&T communities will be challenged to develop or acquire cost-effective clean process technologies and pollution abatement equipment.

The role of S&T in the assessment of environmental and health risks and, where necessary, in guiding the development of regulatory or non-regulatory instruments, is also important. A clear understanding of risk is also essential in order to ensure that Canada's regulatory environment encourages, rather than stifles, innovation and growth.

In Canada, we are approaching sustainable development in a proactive way, not a defensive one. Sustainable development provides challenges and opportunities to Canadian firms and researchers to develop "green" technologies. Application of these technologies will not only be good for Canada's environment, it will also improve the marketability of Canadian products abroad and open opportunities to market the technologies themselves.

The Green Plan recognizes this in its Technology for Environmental Solutions initiative. Industry and Science Canada administers, with the support of the National Research Council and Environment Canada, the Environmental Technology Commercialization Program. This program provides funding in partnership with industry to accelerate the development, demonstration and commercialization of environmental technologies.

I should also mention that Canada is active at the International Institute for Applied Systems Analysis (IIASA) in Vienna. Partly in response to the issues raised at the Earth Summit in 1992, IIASA proposes to conduct research that addresses critical issues of global environmental and economic change. Later this month, a new committee of eminent Canadians will meet for the first time to discuss how Canadians can best approach and participate in IIASA's agenda.

The Canadian government recognizes that science and technology activities are increasingly international in nature, and is committed to the development of strong international ties in cooperative S&T activities. Canada's international S&T relations promote Canadian foreign policy objectives, helping to deepen and improve our relations with both developed and developing countries.

International activities also complement and serve Canadian domestic S&T policy goals, contributing to Canada's social and economic objectives. In this context, the government announced a new strategy in 1989 called Going Global, which has lent financial support to a number of S&T programs, including the Japan Science and Technology Fund. You will hear more about this, this evening, from my colleague, Howard Balloch of the Department of External Affairs and International Trade.

I would like to mention some examples of collaboration with Japan. These are the Co-op Japan program, the Japan Manufacturing Engineers Exchange (JMEE), and the Intelligent Manufacturing Systems Program (IMS).

The Co-op Japan Program sends senior Canadian students in science and engineering to work in Japanese firms as part of their co-operative education program. Beyond the immediate experiences of its participants, the Program is helping to train a new generation of young engineers, scientists and managers to be sensitive to, and knowledgeable about, global business activities. The Program is based at four universities (Victoria, Simon Fraser, Waterloo and Sherbrooke) and is directed at students who have had two semesters of Japanese language training, and, in addition, have taken a special one-month course in Japanese (in Vancouver) immediately before leaving for Japan.

Students have come from a number of technical fields, including computer and electrical engineering, biochemistry, and civil engineering. They have been placed at leading Japanese firms, including

Toshiba, NTT, Fujitsu, and others. While in Japan, they have been assigned to research projects as full members of the companies' R&D teams. Both the students and the Japanese companies participating in the Program rate the experience highly.

Students returning from Japan bring back not only the technical knowledge associated with their research assignments, but also the perspective of how Japanese companies approach projects, an appreciation for Japanese social differences, and an understanding of Japanese corporate culture.

For example, Ming Ho, a University of Waterloo student, spent eight months at Hitachi working on programming computers to recognize speech. Susan Wiedeman, a biology student at the University of Victoria, worked for a Mitsubishi subsidiary with a research group studying immunotherapy for stomach cancers. These young people will be an important basis of future industrial collaboration between Canada and Japan.

The Japan Manufacturing Engineers Exchange was established earlier this year in response to an invitation from Japan's Ministry of International Trade and Industry (MITI). This program is targeted at Canadian manufacturing engineers, who will spend up to twelve months working on the factory floor of Japanese manufacturing firms in production technology. Participants will also spend three months on intensive courses studying Japanese culture and language.

Industry and Science Canada asked the Canadian Manufacturers' Association to solicit applications from selected Canadian firms. The response rate was excellent, with applications received from a cross-section of the Canadian economy, from high technology leaders such as Bell Northern Research through to firms in pulp and paper, shipbuilding, steel and automotive parts. Since the deadline for the first round, the department has also received over 80 expressions of interest from other firms as well, suggesting a strong interest on the part of Canadian industry to become better acquainted at the working level with Japanese counterparts. Assignments to specific Japanese firms are expected to be announced in the near future.

As many of you are probably aware, Canada is participating with Japan, the U.S. and the European Community in the study to determine the feasibility of launching an Intelligent Manufacturing Systems Program (IMS) to develop the production technologies of the 21st century. This study has brought leading Canadian and Japanese industrialists together, both on technical committees and in the feasibility test cases.

In the area of the environment, I am also pleased to note that Canada and Japan are cooperating on several fronts. Canada is lending expertise to the BITEX Program, an international, multi-disciplinary study of the pollution and aging of Lake Biwa, Japan's largest lake and a key resource for drinking water, recreation, agriculture and industry. Another area where Canada and Japan have collaborated is the collection of meteorological data over the Pacific Ocean through the Automated Shipboard Aerological Program (ASAP), which consists of regular balloon soundings of atmospheric pressure, temperature, wind and humidity made by suitably-equipped commercial vessels. This program has been operating for nearly a decade and has benefitted enormously from the cooperation of Japanese car carrier vessels.

At the outset, I discussed the challenge of having a prosperous world economy *and* a healthy global environment. I think that we would all agree that S&T have a key role to play in meeting this challenge. As nations in this global environment, both Canada and Japan have a responsibility, and, I might add, an economic interest, to contribute to the development of the technologies that will make the objective a reality. As Canada's S&T capabilities continue to develop along the lines I have set out, I am confident that we will also continue to explore innovative ways to collaborate with Japan to our mutual benefit and contribute to global objectives.

## General Discussion 3

**Jeff Holland:** Jeff Holland, Fisheries and Oceans. We heard what is being done for the global environment in terms of S&T but we are facing situations of economic constraint, and there is always a problem of addressing long term scientific issues in light of political short term pressures. Could I ask the speakers to give their views on the obstacles that are facing us in our funding of science of technology over the next decade.

**Masahiro Kawasaki:** Yes I agree with you about the need to find the obstacles to solutions to promoting joint activities between both countries. We have had several occasions to talk about the possibility of joint operations, about cooperation in scientific research. But after the implementation phase, both countries face problems regarding financial programs, especially communication. Therefore we need a good infrastructure for the promotion of international joint research or international cooperation. We already have a good framework, especially regarding the earth observation satellites. Someone already mentioned the systems we usually use—the so called announcement of opportunities among the four agencies related to space. That is quite a good indication that there is good cooperation in the implementation of scientific activity.

**Alan Nymark:** I think that the question was asked with a slight smile on the questionnaire's face, knowing the incredible difficulties that Canada now faces in terms of the size of its fiscal deficits both at the federal and provincial level and the degree of international indebtedness which Canada also faces. It is clear that over the last ten years discretionary spending in the Federal Government has declined significantly to the point where the federal government is now in an operating surplus. Expenditures on S&T have held up reasonably well in that context. However, I think the new government, when it opens the books in Canada after the election, will continue to face the probability of severe fiscal restraint over the next couple of years. I think that simply means that there appears to be a general consensus in Canada that S&T is a priority, particularly as we move towards an increasingly knowledge-based economy. One has to look at all the ways possible to protect what we have and to be more efficient in how we expend our monies. As you know the national advisory board on Science and Technology which advises the Prime Minister in Canada has issued a report looking at the possibility of implementing some kind of new system for managing the federal government's six billion so called dollars in expenditure on S&T and I might note that in the United States they have just implemented a new system for managing federal S&T expenditures in the last couple of months. I think also that as Mr. Kawasaki has said, collaboration both with industry which has mixed results in Canada and international collaboration will play an increasing role in light of these fiscal restraints.

**Gordon McBean:** Gordon McBean from the University of British Columbia. I think one of the things that concerns me when we hear these kinds of presentations on science policy reflects back on some of this morning's discussions, where we were emphasizing the uncertainties of the future and in particular the role of surprise. When we talk about managing science strategy and directing it in certain ways, I think we must remember that many of the benefits we are now experiencing as a result of science has arisen out of things which at the time were not and probably would not have been funded for purposes of directed research. Last week one of my colleagues at the University of British Columbia, if I can brag slightly, won the nobel prize in chemistry. He commented in his presentation on campus when we all got together to celebrate this, that at first the paper on which essentially the nobel prize was awarded was actually rejected by the Journal to which he first submitted it. At the time he was told that although it was interesting work they couldn't imagine it would have any practical use. In fact, this particular work was one of very practical significance in the long run. So I guess that we recognize in the science community the difficulties economically, but I wonder if either or both of the members or speakers could comment on how one tries to keep before governments the importance of funding that basic level of research that will provide the ideas—the advances that essentially have us where we are now—not because they were directed but because they happened. Because of scientists working in their innovative way in the laboratories and then connecting to the engineering and industrial communities.

**Alan Nymark:** I was going to wait to hear how Japan does it. I would assume that no one in the room would argue with you, certainly not I. Protecting the creative genius of scientists is a concern that is surely shared by everyone. Just the thought of the concept of managing expenditures raises a certain reaction of who are the managers and how do they know where to make the investments, and will that not in fact stifle creativity. I don't think there is any solution or single model. If one looks around the world the managing systems for S&T vary as widely as there are numbers of countries, so there is no single model out there that one can look to. Certainly, in Canada, I don't think there is any preconceived notion that there's a system that should be brought to bear here and which would have positive early results. The reality is, when you have a dollar to invest you have to decide where to invest it, and somehow you have to have information systems and some form of management system to actually make the decision as to where to invest that dollar.

**Masahiro Kawasaki:** I have no good explanation regarding the problem. Still, we need to organize a good national innovation system. But science and technology policy is not independent from other policies— it must be associated with other political objectives. Another point is that there are different approaches to science and technology policies. Canada, the European countries and the United States are aiming at the development of industry. But Japan has a slightly different position for promoting the so called basic research or science.

**[Unidentified speaker]:** I think I have to emphasize that it is necessary to have some coordination as regards how money is spent on science and technology policies and how it's spent on industrial and also social policies, especially with respect to the environment issues, because I think, unfortunately, especially this year in face of economic depression, environment issues have almost been forgotten or are considered to be a bonus which can be considered only in the case of an economic boom when we have some extra money to spend on them. I think that this is quite wrong, not only in the sense that we have to still try to conserve the environment in the case of hardships, but also I think the growing environment itself could be one goal, even in the case of economic depression. Now in Japan, for example, there has been much talk about how to give a boost to an economy which has been in a depression for several months now. Some people urge government to lower taxes in order to stimulate consumption, especially personal consumption. I don't think this is very good policy, especially as regards long term global environment conservation. I think that the money can be much better spent as, for example, some kind of investment in either research and development, in technology related with energy conservation, or environment conservation. That kind of expenditure could be used to stimulate economy. I sometimes say that the global environment issue is kind of a war against nature, so why don't we spend more money on such kinds of things as the basis of increasing human security in place of the "war against nature", in a metaphoric sense.

**[Unidentified speaker]:** Well, as I read your comments they are a revisal of economics in its purest form. When you are in a recession you ask governments to spend and hopefully they spend the economy through the recession. I think the problem you run into is that when you are already very heavily in debt the impact isn't necessarily the same as you would have hoped. But to a degree, all countries do engage in some sustaining counter-expenditures, as you do in Japan and as we have heard discussed quite a bit in the federal election here in Canada, with such proposals as spending on infrastructure. I think to bridge to your point I would hope that the concept of infrastructure moves beyond filling pot holes and would embrace the larger sense of infrastructure necessary for a knowledge-based economy. In past infrastructure spending programs that we have had in Canada in times of recession there have actually been expenditures made on federal labs, for example, money was spent in areas where there are evident pressures that would have to be met in any event in the future. I think it is also true that you should focus your expenditures in areas that are at least sympathetic to the issue of sustainable development and not counter to the concept of sustainable development. I know in our department of industry and science we very much see environmental industries as being a growth sector and one where we have, I believe, a competitive advantage in Canada. And if one is spending money on infrastructure I think there are a lot of environmentally-related infrastructures where you could spend money wisely. I think I am agreeing with your point.

**John Reid:** John Reid from Environment Canada. In the excellent presentations that we have heard today on science and technology for the global environment, I think we have heard a lot about the inputs into S&T, R&D, dollars, percent of GNP etc. We heard a lot about the structures and the processes that are in place to try and make it happen and some of the activities that are going on such as the exchange programs that Mr. Nymark mentioned. I think what we have not heard so much about is the results and the quantification of results. There was some mention of nobel prizes but I don't think too many nobel prizes are awarded for environmental R&D. I was wondering if this was a fundamental problem with dealing with this issue from a policy context and how you come to grips with success in this area. I was wondering if you have any comments or ideas about how we might do this better or indeed if it is a problem in pursuing environmental R&D?

**Masahiro Kawasaki:** We must be careful in two respects. One is that we can look at the tangible result, for instance some of the software that has been developed. That is tangible. But we need also to consider the intangible aspect of science and technology activities, especially regarding the research and including the mutual experiences or sharing. It is quite difficult for us to evaluate such intangible results from science and technology activities. R&D activities are continuous activities. Every day there is a small change or more advances. Therefore one must also be careful of time frames. That is only my comment. I have no solution.

**Alan Nymark:** I don't think it is unique to S&T in Canada that we tend to attribute supply side solutions to problems to a lack of performance on the part of the private sector. Training is another one. You often hear "why don't our firms train more," on the basis of international comparisons with other countries. "Why don't our firms invest more in R&D in comparison to other countries." I don't have simple answers to those questions, but I think this is where the importance of collaboration and partnerships comes in. Somehow you have to link into the demand side of this to see who really wants done what we are doing in the S&T side.

**Lawrence Mysak:** First of all I would like to support Dr. McBean's point about supporting basic research. I have seen so many times, in my own work and that of other colleagues, that we must continue to support basic research. In fact I would just like to mention that the Royal Society of Canada, in cooperation with ten leading research universities, has published a little flyer titled *Basic Impacts,* containing success stories that show how fundamental research has lead to excellent cost savings and the solution of very basic problems. These have been so popular in fact, that we can't keep up with the demand.

What I would like to do is raise a specific question to Mr. Nymark concerning our tremendous budget deficit. Okay, we only have so much money for research, so much for basics and so much for different government departments. What processes are there in place or what mechanisms are there for establishing priorities of supporting science in the federal government?

**Alan Nymark:** There aren't many mechanisms—or maybe I should put it the other way around—there are too many mechanisms and thus there is no really effective way to establish priorities for S&T expenditures in the federal government, let alone coordinate with provincial governments. The Prime Minister has indicated in the course of the last eight weeks that it would be a priority of his to look at this issue in the near future. I think that by and large S&T in the federal government has grown up historically. Therefore, it is very difficult to alter them. It is relatively easy to alter priorities when budgets are growing and there is incrementally new funding. People are willing to accept some level of direction and management and the terms used by someone else when it is a matter of how much new funding you will get. But when it is a matter of existing funding and how that funding is meeting some broad national priorities it gets more difficult. I don't have a solution to propose but as I say I think we should probably be looking very carefully at some of the systems around the world that are in place now and seeing whether they have any relevance to the Canadian system.

**Ian Rowe:** This is a question I guess partly to Alan. Its a question for all of us. I would like to attack one of the icons of science funding and it is the following. What we say about collaboration and what we do in our institutions are quite different. Institutions, particularly universities, we will call the cult of the individual. The individual professor is all important. His papers and his individual contributions are what's judged through institutions like NSERC and so on. Tender and promotion is all based on supporting the cult of the individual. Could you imagine what a Honda would look like if it was assembled by professors each working with the notion of the cult of the individual. One designing the wheels, the other the engine, and talking to each other maybe annually, if they meet. Global change is a large, large problem. How does industry approach a large problem? It takes a systems viewpoint, it sets up objectives, it looks at its human resources. It allocates those resources to problem solving, exchanging information regularly, continuously reviewing the objects, reviewing progress towards those objectives and moving towards a single solution. I suggest to you that the financial institutions in Canada, the U.S., the U.K. and other countries, will not contribute very well to solving global problems unless we adopt a systems approach. In the systems approach there is not room for the cult of the individual except where that contribution plays a greater contribution in satisfying the ultimate objective. So to you Alan, I say that I think NSERC is a wonderful engine but it is championing the cult of the individual, and as I do analysis of supporting networks, those networks are again networks of individuals working in their own separate areas. I suggest we have a fundamental institutional problem that has to be addressed before we can address a larger problem like global change.

# 4. Roles of Canadian and Japanese Science and Technology—Panel Discussion

***Moderator:*** *Dr. Lawrence Mysak, President, Academy of Science, The Royal Society of Canada*

***Panel Members:***

- **Mr. Yoshio Okawara**, Executive Advisor, Federation of Economic Organizations, (Keidanren); Former Japanese Ambassador to the United States of America
- **Dr. Hirohisa Uchida**, Professor, Faculty of Engineering, Tokai University; Head, Uchida Project-Research Laboratory, Kanagawa Academy of Science and Technology (KAST)
- **Dr. Geoff Holland**, Director General, Physical and Chemical Sciences Directorate, Fisheries and Oceans Canada
- **Dr. Alex Chisholm**, Science Advisor, Environment Canada
- **Mr. Michael Kirby**, Vice President, INTERA Technolgy Co. Ltd.

**Lawrence Mysak:** It is a pleasure to be here and I think we are witnessing an excellent dialogue between Canada and Japan on global climate issues and the environment. I have the pleasure now of introducing our very distinguished panel. I am going to follow the order in the program rather than the way they are seated here to my right.

First, Ambassador Yoshio Okawara. He is a graduate of the Imperial University of Tokyo—a graduate of Political Science and Law Administration. He joined the Ministry of Foreign Affairs in 1942 so he has indeed had a very long and distinguished career. After various appointments in Europe, Asia and the United States, he became Ambassador to Australia and then to the United States. He officially retired in 1985 but like a lot of active minds he has continued to play a very dynamic role with many different ministries as an advisor or executive advisor to, for example, the Minister of Foreign Affairs and to the Federation of Economic Organizations.

Next I will introduce Dr. Hirohisa Uchida who is a graduate of Tokai University, in Applied Physics and Material Science. He also has a doctorate from Germany where he lived for many years working at the Maxplac Institute for metal research. He returned to Japan in 1981 and took a position in the Faculty of Engineering with Tokai University. He is now leader of the Project-Research Laboratory in Super Magnetic Materials at the Kanagawa Academy of Science and Technology.

Mr. Michael Kirby, the next person on our program, has a bachelors degree in Physical Geography from the University of Windsor and a masters degree from Waterloo in Remote Sensing and Imaging Processing. He has been with Intera Corporation since 1976, and has played a key role in the development and management of the corporation's international remote sensing business including corporate space initiatives with Japan. He has worked on radar technology with Japan, and this program was instrumental in Japan's space program known as the JIRST One.

Dr. Alex Chisholm is an Atmospheric Scientist with degrees from the University of Alberta and McGill University where he studied meteorology, both at the masters and doctoral level. He also spent a year at the National Defence College in 1980. His career has been with the Atmospheric Environment Service working in various areas of atmospheric physics, physical meteorology with such things as cloud physics, hail research and rain enhancement. He later became Director of the

Atmospheric Processes Research Branch and then Director General of the Atmospheric Research Directorate. He is currently the Science Advisor of Environment Canada.

Finally I would like to introduce Mr. Geoff Holland from the Department of Fisheries and Oceans. Faculty Director General of the Physical Chemical Science Directorate in Ottawa, Mr. Holland received his original training in Mathematical Physics, has a masters degree in Fluid Mechanics and for ten years worked on hydraulic research. When he came to Canada he began a career with what is now Fisheries and Oceans, working on a study of wave activity around the country. Over the years he has become more active in the promotion of various large-scale science projects within Fisheries and Oceans and in particular he has been very active, as I know personally, in supporting the ocean component of the World Climate Research Programme, the World Ocean Circulation Experiment (WOCE). He has also been active internationally and was just recently elected the first Vice Chairman of the Intergovernmental Oceanographic Commission, which is an international organization.

With those introductions I would like to comment briefly on the format for this panel discussion. We have asked each of the panel members to make a four to five minute presentation relating to the theme of the workshop, and perhaps bringing out their own areas of interest and expertise. I will proceed in the order that they are seated, starting with Dr. Chisholm. Following the presentations I will open the floor to discussion for questions directed specifically to the speakers and any of their remarks, and then we can also open the floor to questions or comments on any of the issues that have been raised today. I think our goal with this session is to look at possible future areas of cooperation and collaboration between Canada and Japan in the environmental area and perhaps to establish some priorities.

**Alex Chisholm:** I am not going to spend a great deal of time. I am just going to run through a number of slides and remind people of some items that are consequential to the environment. Environment Canada ran a science forum about ten months ago. This was a gathering of approximately 50 of our scientists, roughly a quarter of the total population in Environment Canada. Some of the priorities that came out of that exercise represented not only the people who were present but many of their colleagues with whom they had discussed these items. It really confirmed our views about a number of things scientifically. First, that global warming is, without question, one of the highest priority items within the department. Number two is population, consumption, and economic growth which was addressed by Professor Takeuchi this morning. This is something our department has not spent much time on and we are still a little puzzled on how we might tackle it. Toxic pollution is no surprise; our department does a great deal of research work on this. These are sort of code words for things like pulp mills, acid rain, urban smog etc., but something that was a little bit of a surprise was biodiversity, perhaps not a complete surprise in view of the fact that Canada has recently signed a convention on this. We are presently doing a science assessment on that particular topic. But it was combined with the idea of equal systems sustainability which is something our department is trying to do something about in the Fraser River, the St. Lawrence and the Great Lakes, at least.

Last, but by no means least, an area where environment Canada has put a lot of work, ozone depletion but more the UVB impact was felt to be an area of increasing concern. That's the one I have to concentrate on in the next couple of minutes. There is no question that there have been significant increases in UVB radiation. There is little question that the ozone layer will continue to deplete for another twenty years or more so UVB radiation will increase. This will mean major food crops which are sensitive to UVB radiation are going to be affected. Certainly fresh water aquatic ecosystems are being effected now. What we don't know is what kind of adaptation mechanisms there are and an understanding of those are essential. And ecosystem feedbacks are really very complicated in terms of sulphur and nitrogen and heavy metal cycling through the food chain. So the research needs are pretty obvious. It is a necessity to undertake UVB monitoring. This is something that's not done well throughout the world. I think it is fair to say that Canada has quite a lead in it and can assist in this matter. Theoretical models from both the biological and a physical view point are essential as are lab experiments and, by no means least, experiments in the field to try and determine what's happening in real life.

The implications are really threefold. Global food supply, particularly every protein crop, is affected substantially by UVB radiation; fish of all kinds, both in fresh water and ocean circumstances; livestock are also affected and so there is a need to increase understanding to find ways that we can devise adaptive technologies so that we can work our way around this. And what are the ecosystem's limits? What do we need to know to essentially understand and deal with this sort of thing in the future? Ultimately of course, we need international cooperation because this is a global problem. Thank you very much.

**Yoshio Okawara:** You know and I know that when expectations are high, consequential disappointment is all the more great. Since I am not scientist, nor an academic, I would like to address myself to the broad framework for collaboration between our two nations, which will serve as the basis for other cooperation, particularly in the field of science and technology which is the main theme of discussion today. It happened that I was a co-chair with Mr. Peter Lowhead for Canada-Japan 2000. In that report we stated that our two countries are remarkably diverse in terms of natural conditions, the processes of nation building, political and administrative mechanisms and make up of the people. Taking advantage of all the differences, the two countries complement and enhance each other, much like pieces of a jigsaw puzzle when they are put together. Behind this lies the strong bond of sharing the same values and unshaken commitment to democracy and a market economy.

Now I think there is a basis on which we can build a broader cooperative relationship, hopefully by way of a partnership across the Pacific. In the very rapidly changing world circumstances, no single country can indeed cope with the very high magnitude and highly complex nature of the problems. Since Canada and Japan share some of the common objectives, we can build on that basis. When the world is experiencing very rapid changes, such complex issues raise even greater world-wide problems such as refugees, population growth, environment, drugs and so on. These problems are a tremendous challenge for the whole world community. The relationship between Japan and Canada so far is primarily related to economic matters because of the economic contacts developed over many years. This is a time for both of us to develop much broader bases of cooperation, not only confined to economic areas but also political, cultural, scientific, and technological for sustainable growth.

Both countries should identify and as a follow-up collaborate on the development and the progress of technologies. For this particular purpose, Japan and Canada should move towards a joint observation satellite by the year 2000 for ongoing monitoring activities on atmospheric, oceanic and natural resources. This morning many speakers talked about this area of cooperation and I was very much heartened to hear such observations about activities reported in our joint report of Forum 2000. This morning's newspaper reported that Russia dumped nuclear waste and nuclear material into the water of the Sea of Japan. Naturally Japanese people are very much concerned with this kind of development on top of the prospects of global warming and greenhouse effects, which have been mentioned so often here today. We also have a problem with China, which has been aiming for modernization of its economy and industrialization. As a result of their efforts in this direction, they have caused air pollution and acid rain resulting from coal burning, which has been causing tremendous problems for Japan. These problems cannot be tackled simply on a bilateral basis. We need very extensive multi-national cooperation. That is the reason why we feel that very strong cooperation between Canada and Japan, particularly in the field of science and technology, are very much today's urgent need. I am very happy to recognize that at today's meeting on the future of the global environment which was sponsored by the Honda Foundation in cooperation with the Royal

Society of Canada. This is one example of how we can cooperate fully in that direction. I also should mention that last weekend the Honda Foundation organized a symposium with the full support of the Canadian Institute for Advanced Research. That is a very clear indication that in the private sector we are now developing closer cooperation for the sake of public health and human well-being.

**Michael Kirby:** Thank you very much Mr. Chairman, ladies and gentlemen. It's a privilege for me to have the opportunity to talk to you today and it also is a privilege for me to happen to belong to one of the sectors in earth observation where Canada and Japan have actually collaborated for quite a number of years. Canada, through the Canada Centre for Remote Sensing and now through a variety of institutions and universities and colleges, has been working with the Japanese in areas of observation for more than a decade and overall the benefits from that, technical and otherwise, have been quite extensive. Just to give you a quick overview of some of the programs that have occurred (I am focusing on the space-borne side), there are a number of missions: MOSS-1; JERS-1; RadarSat, which is now getting into its next phase; and a variety of other programs that Canada and Japan have worked on which include data from European countries as well as America. The future holds quite an extensive number of missions being planned by Japan and certainly by Canada, where additional collaboration not only could and should occur, but I think would actually be necessary for these programs to be useful internationally. The interesting thing about it is that it offers a greater opportunity for our two countries to work much more closely in the future, but I believe that it requires something that perhaps Canadians are certainly less adept at than the Japanese, and that is to take more of a strategic view of what will happen with our objectives in the future. Perhaps on the earth observations side what we could jointly do, and I think this requires more of a will from Canada than Japan, is to develop an objective where we would form a strategic partnership with one another and share some common and cooperative approaches in the development of appropriate earth observation science and technology, and it should be done in order to address world environmental needs.

A couple of key aspects here, at least from the Canadian point of view, are the importance of strategic partnerships. That is, we tend to develop partnerships that work on a project to project basis, whereas the Japanese have been very good at developing strategic partnerships that go through generations and serve the world's environmental needs. In other words, we try to develop partnerships that do not include just what's going to benefit Canada or what is going to benefit Japan, but as a strategic partner, we go out into the world and try and serve other countries as well with these initiatives.

How can we do this? Well I think there are some very encouraging things happening already but we need to apply more attention and resources towards it. On the technology side, there are certainly ways where we can, from an earth observation point of view, share—space segmenting, ground segment and technology, personnel exchanges, and certainly we can exchange knowledge. And then from the data side there's archiving, distribution, and analyses.

Finally, here are some of the obstacles I think that we need to look at in terms of a strategic partnership in this area. We have to look at the different ways that we view our methods between the two societies and in the approaches that we take to our work. And as I mentioned earlier, time frames are important. The Japanese tend, from the little I know of it, to take long term multiple-generation views while unfortunately Canadians are often at the will and vagaries of the next federal government, depending on who gets in. Our wish is to get a majority government, but then again who knows? Often competing priorities for funding and other resources to meet these objectives are very serious elements and we certainly have heard of the impact and we have all felt the impact of the recession in that regard. But we need to try then to align some of our common objectives so that we are not working at cross-purposes. If we can in fact form a strategic partnership between Japan and Canada, we both have very advanced technology, we have appropriate infrastructures. I think both countries realize the importance of mixing government priorities and budgets with industry objectives as well as the academic community's objectives. And although Japan's investment in this area is orders of magnitude larger than Canada's, the approach is very similar and I think we can capitalize on that a bit.

Then of course we are generally well known in this field internationally and we have high visibility, and so finally through a partnership that's strategic, I think it could be a powerful model for the rest of the world and certainly help us for the future in developing our programs. Thank you very much.

**Hirohisa Uchida:** Thank you, Mr. Chairman, ladies and gentlemen. As pointed out this morning, we need actual collaboration between two countries. Therefore, as an example of that I would like to point out important roles of academic sectors such as universities and research institutes with a brief introduction to activities and projects proposed and actually undertaken by university scholars in the Asian and Pan-Pacific region.

The first Conference of the Asian and Pan-Pacific University Presidents started in 1987 in Tokyo in response to the agreement of both university presidents, Dr. S. Matsumae, Tokai University, Tokyo and Dr. J. Mayer, Tufts University, Massachusetts. This conference suggested that university scholars must confer on issues such as exchange programs, cooperative projects and curricula in order to promote world peace. From their commitment to this ideal has come a series of meetings of university presidents, institute directors, scholars and academics devoted to international efforts to increase harmony among people and with the natural systems which sustain the Pacific region.

In the major meetings held, the title of the first conference was "Toward a More Active Role for Peace and Stability" and that was organized by Tokai University, Tokyo, in 1987. And the second conference with the title of "For Peace and Prosperity in the Asian Pacific Region", was organized by Tokai University, Tokyo, in 1989. The title of the third conference was "Global Environmental Protection and the Future of Humanity". That was in 1991 and was organized by Far Eastern State University, Vladivostok, Russia.

In accordance with the Vladivostok Declaration, a workshop titled "Marine Environmental Project, North Pacific Ocean Meeting" was organized and held in Honolulu in January 1992 by Tokai University, University of Alaska, University of Hawaii, the University of British Columbia and Far Eastern State University. One of the activities organized among these universities, the buoy floating experiment from Japan to the Hawaii Islands region, started at that time and is being continued by an international collaboration of these universities using satellite monitoring and marine observation in order to confirm the path of floating debris polluting the Pacific Ocean.

The fourth conference was held in September, 1993. The University of Alaska organized it under the title "Our Common Shores and Our Common Challenge: Environmental Protection of the Pacific".

Each of these meetings has brought together an international group of intellectual leaders to address issues vital to mankind, and each has resulted in a Declaration encapsulating the concerns, the hopes and the plans of the participants. The goals are high and some of them remain beyond human reach. This is evident if we recognize the fact that we are confronting many problems we cannot solve by conventional ways of politics or science and technology, as Professor Takeuchi pointed out this morning. The paradigm of conventional science and technology consists of elements of materials, energy and information. However, the end of the Cold War and the unification of the East and the West have displayed much more complicated and broadened issues in which we have to recognize the existence of many different value judgements and decision-making processes which depend upon specific cultures, religion, race and regional history. These issues cannot be dealt with in a conventional political way nor a simple technological way.

In addition, we are confronting newly appearing scientific and technological issues like DNA-control, birth control and the definition of death, by heart or brain. These intrinsically scientific and technological issues seem to require new ethics. The incorporation of the additional elements of life and humanity into the conventional paradigm of science and technology seems crucial for our future. In this connection, effective environmental education seems vital for the mutual and equitable benefit of present and future generations.

Through these university meetings, we are declining to focus our attention on the global environment and on the balance of the global environmental ecological system because the issues of rapidly growing world population and increasing distance between the poor and the rich are incorporated into the sustainable use of the global environment and resources.

Ladies and gentlemen, we, mankind, are often egocentric. We have to know that environmental deterioration may not be a crisis to the earth, which has existed for 4.6 billion years and will exist for more than 5 billion years in the future, but the deteriorating environment is a crisis to mankind—one involving 1.7 million lives on the earth and one which has markedly affected the global environment by consuming a huge amount of resources and energy within a short period. We cannot reverse our time or renew the global environment. However, our posterity may exist longer on the earth if we act to protect our environment and try to search for pathways to coexist with other lives.

In this connection, I would like to emphasize the importance of international cooperation in environmental observation, and education in academic sectors, by using one of the items of the last Alaska Declaration: "University scholars in the natural sciences, economics, policy analysis, international law and other fields have a special obligation to understand the processes which regulate the environment and its living resources, and to search for sustainable pathways of human development and to teach others about these matters."

The next University Presidents' Conference will be hosted by the University of British Columbia in Vancouver, Canada in 1995. I hope for continuous and actual cooperation in the fields of science and technology, and education between Canada and Japan. Thank you very much.

**Geoff Holland:** Good afternoon. You can probably guess from my title that I am going to address ocean issues. I would agree with Mr. Okawara that when dollars are scarce, it makes sense to cooperate internationally and bilaterally to address common priorities. Canada and Japan have a mutual interest in the oceans. Canada has one of the longest coast lines in the world and vast coastal territories and coastal zones. Japan is an island country whose society and economy is closely linked to the sea and its resources. And although the land masses of both countries are totally different geographically, we both share the waters of the North Pacific Ocean. We are both affected by the climatic changes of those waters and the sustainability of the living resources they contain. We already cooperate through the World Climate Research Program under the new North Pacific Science Organization that you can see on one of the poster sessions. And again, as Mr. Okawara pointed out, there is the Forum 2000 with recommendations that Canada and Japan share the stewardship of the North Pacific and cooperate in that program.

Off Japan's eastern coast and the Gulf Stream of Canada's eastern coast are two of the most important of the world's oceans—systems similar in nature—being examples of western boundary currents, and both have major impacts on weather and climate in the fisheries resources. Oceanographers in Canada and Japan share a need to understand and predict the processes involved. A shared and fundamental need for improving the understanding of the oceans and its changes lies in the development of more effective monitoring devices and systems. Both countries have indicated a strong interest in participating in the intergovernmental program, the Global Ocean Observation System, so called "GOOS". The GOOS is a part of the Global Climate Observation System (GCOS) and covers all aspects of ocean measurement, from climate changes to ocean health and coastal zone management. The development of cooperative measurement programs and new technologies form an important part of this program. Japan has a strong capability in many related areas: ocean engineering, electronics, micro computers, satellite observations, to name just a few. Canada has also demonstrated many areas of expertise complementary to ocean monitoring such as underwater acoustics, robotics, information systems and modelling expertise. An examination of the needs for ocean monitoring and measurement systems in the North Pacific can be confidently linked to subsequent partnerships in the development of automated technology to deliver the required data and present the information effectively and efficiently. We have already heard of satellites and the earth observation system. We also need satellites for the global positioning systems and for data transfer for vehicles that can measure the characteristics of the underlying waters, pop up to the surface and transmit that data to shore.

In the Arctic, despite large geographical differences, again we share a reputation and interest in Arctic oceanography. Canada has many opportunities, more opportunities than Japan for Arctic research with large Arctic territories, and we can cooperate in the training and Arctic climate measurement programs.

With our fisheries, the effect of climate change on fisheries is something we both have to study. Not only the effect of temperature change on individual species but on the interaction of species and populations. Even this year with warmer water up the West Coast, we got species like mackerel coming up and preying on the young salmon, which may lead to the collapse of that fish in a few years, and this is just an inter-annual event. Just think what can happen when these changes are more permanent.

With population, the demographics show that 80% of the world's population could live within a hundred miles of the coast in a fifty years time. The pollution pressures on coastal zones and high seas have to be addressed. In my own opinion, the population pressures will also spread into the three-quarters of the world's surface that is ocean. We are going to move into the ocean spaces by ocean farming and perhaps even by creating living space on the ocean surface. This may not take place for ten years, but it will come I am sure. When I was in Japan a few weeks ago, I was impressed with work they were doing on the deep ocean. They were looking at the biodiversity of the ocean communities. These are parts of the world ecosystem that haven't been studied. They survive under an atmosphere of extremely high pressure and sometimes water temperatures of 300°C. What could these organisms do for our chemical industries if we could only harness them and find out about them?

The Japanese have also studied volcanic vents. They found a rift in the ocean floor off Japan that they felt had just been caused by one of the recent earthquakes, and were monitoring it over several years so they could possibly predict the next sequence of earthquakes that would generate from the area. In the western coastal zone of Canada we have vents with biological communities that are completely different from anything that has been studied before. Both countries cooperate in the ocean drilling program and share the possible benefits that program could have for studies of the marine sciences.

In all of these areas, I think that both countries can save a great deal of their scientific and technological resources by cooperating, first of all in the scientific programs and in defining the science that is needed, and then following up by transferring this into the technologies that are required. We have a great synergy in our expertise and we have a great synergy in our interest, and I think the different or the common connection of the oceans in the two countries will allow us to profit by bilateral cooperation. Thank you.

**Mr. Chairman:** I now open up the floor for questions to any of the panel members.

**Gordon McBean:** Gordon McBean from the University of British Columbia. I just wanted to follow up on some of the comments that Jeff Holland just made about the oceans and the connection across the North Pacific, and wondered if we could hear more from our Japanese colleagues, either those on the platform or perhaps those in the audience, who could elaborate on how they see these exchanges and relationships in terms of ocean monitoring, interest in ocean ecosystems from a marine culture and other points of view?

**Hirohisa Uchida:** If I had more time, I would like to explain something about the buoy experiment because you are from the University of British Columbia, aren't you? In October last year, we dropped off a series of buoys and in January this year, some of them had reached Hawaii via currents and eddies by which debris is collected. And this year, 100 Argos buoys will be dropped off and if they get to Hawaii, then the ships from the University of Alaska and the University of British Columbia will go there and confirm it. Until now we have had very good collaboration and, I think, this collaboration is going to become broader and much better. Thank you.

**Grant Ingram:** I would just like to mention in terms of the ocean side of things that Mr. Holland was mentioning that there has been a rather successful collaboration that lasted from late '89 through '92, with Japanese scientists looking at the Arctic, in this case looking at sea ice. We were looking at sea ice variability and there were ten Japanese scientists from government and universities, likewise from Canada. There wasn't total funding for the project—it was somewhere around 35%—so the remaining money had to be found. I would say it has been very successful and has led to further research in the year and a half following that. With Japanese scientists the project is ongoing and this is planned for the next five to six years. It was funded under the Japan-Canada Science and Technology fund of External Affairs. Are there plans to keep that program going or are there similar models visualized for the future?

**Hirohisa Uchida:** In connection with a previous question and in addition to my earlier comment, our experiment is supported by a TV broadcasting company, an FM radio broadcasting company, and also by the John Lennon Foundation—by three supporters in all. The experiment itself is quite interesting because if we put out 100 buoys, they don't all go to Hawaii. Maybe 30% of all the buoys are expected to reach there. Some buoys reached another country and were opened, and then we lost the signal. And some of the buoys were caught by the Japanese Maritime Safety Agency and the signal went back to Tokyo, then they telephoned to say "You lost a buoy." Also the battery in the buoys had some problems. The batteries would break: some of the batteries would go for one week, some for one month, some for one year, and so on. We don't know why. Anyway, that was only one collaborative experiment, but I think this is the first step for future collaboration. In this series of Asian-Pacific university meetings, we have three working groups. One is satellite monitoring, the second is environmental education and the third is involved with the sustainability of the pacific ocean. If you have some interest in these activities, I can send you some information. I suppose the University of British Columbia can also send some materials. Thank you.

**Yoshio Okawara:** Perhaps I should refer to a particular portion of our report from Forum 2000. Dr. Holland mentioned stewardship of the North Pacific Ocean. Our report stated the North Pacific Ocean links, and does not divide, most countries in the region in resources, social environment and trade. The initial objective of this project will be to monitor and define the factors affecting the pollution of the ocean which will impact on the sustainability of fishery resources. By doing this, we can determine what action is necessary for pollution prevention. As has been mentioned earlier, the important point is collaboration between our two countries, at the government and private level and so on, but the idea of stewardship of the North Pacific Ocean was particularly emphasized by Canadian members of the forum, and the Japanese members shared the basic approach. We hope that through ongoing channels of communication and contact this idea will be further expanded.

**Frank Campbell:** I'm with Natural Resources Canada. In following up on the invitation to table other areas of cooperation with the Japanese, this is again under the umbrella of the Japan-Canada S&T fund, we have been working at trying to develop collaborative technology programs on the energy efficient housing front with the Japanese. We had a very successful workshop in Whistler, B.C. last June just prior to a conference on innovative housing, and we have identified about six areas in which to try and develop specific cooperative projects. I caution that it is a time-consuming process as most of you probably know, to try and actually nail down specific pieces of work and where both sides are going to do something instrumental outside their existing programs. Thank you.

**Allan Carswell:** I'm with York University and the Institute for Space and Terrestrial Science. I just wanted to make a few comments on the recent but I think excellent collaboration that has been going on in the Canadian high Arctic involving researchers both from Canada and several Japanese groups. Many in the room will be aware of the fact that under the Green Plan, during the last year, the Atmospheric Environment Service of Environment Canada established the Arctic's stratospheric observatory at 80 degrees north, near the permanent weather station at Eureka. This laboratory has many purposes, all associated with taking a long-term view, with many sensors, of the Arctic stratosphere and looking particularly at the ozone problem and its associated chemistry. What you might not be aware of is that since its inception at this laboratory, there has been a very active and vigorous participation by Japanese colleagues. I think this is an example of a project that really grew up from the grass roots commonality of interest of these researchers. This station has been designated as one of the primary Arctic stations in the newly developed network for the detection of stratospheric change. This is authorized by the WMO and is being coordinated by NASA in the U.S.

We have already heard in the last two comments of the importance of the Japan-Canada Science and Technology fund. The Japanese were able to come up with some of the funding to support the area that we work in—that is in light measurements. Environment Canada supported the cost of one light, the Japanese supported the cost of a second light, along with the Canadian fund, the Japan-Canada fund. Both of these systems were in fact built by a Canadian industry which now has the capability and is marketing this technology abroad. In the first winter of operation, excellent data were obtained, and in about two weeks time all the teams from the various Canadian and Japanese groups are going north again. We are measuring many things that have never been measured in the Canadian Arctic before. I think the comment I wanted to make is that we sit with such a project being driven primarily by the interest and the funding available to the individuals, both at AES and the universities and the Japanese institutes, with each member having to apply for the program and for the support to their own agency. I think such a collaboration would benefit greatly because it's long-term, and it's of strategic importance to be part of a longer-term strategic collaboration between the two countries so that we can jointly plan and not be quite so dependent on all of the short-term variabilities. I think this is an excellent new Canadian initiative and is going to provide us with a whole new set of information on the Canadian Arctic.

**Lawrence Mysak:** I should mention that next week there will be a very important summit meeting on population in Deli. This has been initiated by the lead academies in the world: The Royal Society of London, The National Academy of Sciences in the U.S., the Indian Academy, the Third World Academy of Science. There has been a population summit statement prepared in draft form and this has been signed by the Royal Society of Canada and will be distributed to the press. I am glad to see the population issue has been discussed here and is very much on the minds of lead academies around the world.

**Michael Keating:** I am on the Board of Directors of the Global Change Program. My responsibility, to put it front and centre, is chair of the Communications group, so I would like to put a question to our Japanese colleagues here. One of the problems we are wrestling with, and you have heard it addressed in different ways today, is how do you communicate complex scientific issues, findings and uncertainties to people who, to put it bluntly, pay the tab, but also the people who need the information to make political, business and personal decisions, because it's finally, as somebody said, public opinion that drives a lot of the political decisions and consumption patterns which then set the economic agenda. One of the problems we are wrestling with in Canada is, how do you organize yourself? How does a scientific research community organize itself to communicate the knowledge that the experts have to a whole series of audiences including, if you like, the sort of surrounding experts, people who don't always make it to these meetings, consultants and various other people who need this information and are communicators. How do you communicate to the policy-making people, bureaucracies and elected officials at all levels of government? How do you communicate to the business community, which is really the driving force for change, in the positive sense, I hope? I am looking for suggestions as to what the experience has been in Japan and other countries and, quite frankly, are there openings for collaboration and sharing of our experiences and knowledge?

**Hirohisa Uchida:** As I pointed out in my talk, it is necessary that we change our concept of science and technology because until now we believed that science and technology were very powerful. But now we are confronting so many problems that cannot be solved by conventional science and technology. The problem is so different according to the country. And this complexity is true with respect to communication and collaboration, too. I wanted to ask somebody here and get an answer back because in my opinion, I see that the change of the paradigm of science and technology is quite necessary. That means we have to shift our standpoint to another position within a frame of energy, material, information, and also life and ethics. In this connection, I find, education is very important to children or the younger generation; if we discuss things with old people or adults, it may be too late for them to become conscious of the issues. There are so many examples of the necessity for change in decision making and ways of thinking. For example, DNA control, you can change or you can determine it. In other cases, as Prof.Takeuchi said, population control is not birth control but death control, too. How should we think about it? These are strongly connected with the just-arising issue of the paradigm shift. As an example of difficulty and complexity in communication and collaboration, if we look at environment problems, it is not easy. Today we are discussing Canada and Japan. But please imagine if Canada and some poor country got a conference going on the environment. It is very difficult. The actual problems concerning them may be religion, hunger or poverty, and so on. What we are now discussing is a very ideal thing.

**Yoshio Okawara:** Change of paradigm, that is a very important factor which we are experiencing these days. These are day-to-day affairs we are faced with. Without some change of attitude and position, we simply cannot follow. We cannot cope with very rapid development and change in Japan these days, particularly in the field of science and technology. As mentioned earlier by Mr. Kawasaki, there is a problem in Japan in the field of research and development. R&D in Japan has primarily been conducted through private sector cooperation, business cooperation and so on. But, because R&D is conducted by business cooperation it is naturally directed towards industrial applications. On many occasions, R&D done openly for the sake of business cooperation has developed a particular area of products as a result of in-house R&D. These days though, the Japanese government has been trying to emphasize a contribution by the public sector, meaning governmental R&D should be further expanded with additional funding by the government. But, as mentioned by Mr. Kawasaki earlier, even in this area there are problems because of a very tight budget situation and very much a fixed notion of the traditional propitiation of various important elements. But this is a time for Japan to exercise change and to change the paradigm. The proportion of emphasis, say, between the private sector and the government sector will be undergoing changes, though at a gradual pace. But how to communicate to the people concerned is another matter which has been mentioned by the speaker. In the age of information revolution even people who are not directly associated with science and technology area have to come to grips with the changing situation in science and technology.

**Masahiro Kawasaki:** A few years ago both the governments of Canada and Japan established the so-called Wisemen Committee on cooperation over science and technology. At that time the president of the National Science Council of Canada and this committee had a mission to question what should be done in cooperation between Japan and Canada. The second question is what *can* be done in cooperation between Japan and Canada. We need a similar function now to observe, review and comment for more cooperation in the science and technology field.

**Lawrence Mysak:** Can anyone speak to this to explain a little about communication problems in Japan and in answer to the question asked, especially integration with global environment issues. Much public interest has been raised about this question in various sectors. I have experienced that, having had discussions with those people, and I think that most of the major companies, including the big companies in Japan, have special sections dealing with global environmental problems. Major associations of business executives have also established committees to deal with the problem, and so on. And also, as Mr. Kawasaki shows, almost all ministries of Japan have a section dealing with global environment problems in some way. But the most important thing is how to get common understanding of the problem. Of course we can't immediately have the solution for that, but I think the most important thing is communication to the public—not a conversation between academic workers belonging to the different branches of science. I think that the social scientists must be more, should be more involved. What the global environment has shown is that the thinking of social scientists must be changed, must be transformed. Especially, for example, the economists—we now need a major transformation in the basic framework of economic thinking. This includes the concept of scarcity of resources, and usually the resources consist of three components: labour force, capital stocks and natural resources. Now most of the scarcity of resources are natural resources, and the most abundant thing is human resources. But we have been obsessed with saving human lives at the cost of wasting natural resources, which is exactly what you shouldn't do. So I think we have to change our way of thinking and also change economic thought. I think basically we need so to speak a very fundamental discourse with different branches of people, different scientists belonging to different disciplines. And also it would most fruitful if we could have social scientists coming from different countries with different backgrounds in history and also different social structures and so forth. So I would like to propose that social scientists of both countries, Japan and Canada, could be more involved in intercontinental discussions.

**Les Shemilt:** Les Shemilt from McMaster University. Ambassador Okawara mentioned in passing the recent problem of radioactive waste disposal by the Russians in the Sea of Japan. I think it might be worthwhile for the record to note two aspects with regard to that type of global environmental problem. Firstly, there is a long standing Canada/Japan cooperation at work with regard to research on radioactive waste management. It is taking place in the underground research laboratory of AECL near the White Shore Laboratories in Manitoba. There is a second area in which Japan and Canada are just two of the nations participating in a multinational project which is just at the stage of being launched. This refers to a project under IIASA that Mr. Nymark noted earlier, in which Canada was a participant. The International Institute for Applied Systems Analysis is a nongovernmental organization centred near Vienna. It is operating with fifteen member countries at the present time, including Canada and Japan. The new project that is under way is Radiation Safety of the Biosphere. The advisory committee running this project includes Professor Takeuchi of the University of Tokyo as one of the eight-member advisory committee. There are six nations on that particular committee. They will be working on an initial phase of a two-year project relating to both data gathering and illumination of the current methodologies available for some of the environmental problems relating to radioactive waste, particularly in parts of Asia and the former Soviet Union, but with implications for radioactive waste management world-wide. I simply mention this to indicate that there are arenas in which Canada and Japan cooperate, and cooperators can and will participate in multinational efforts.

**Geoff Holland:** I would just like to add something to the comments of the last speaker. In terms of the disposal of radioactive waste into the ocean, Japan and Canada are both members of the London Convention which deals with waste disposal, and that actually will be consolidated at a meeting in a couple of weeks. Canada and Japan are consolidating at the intergovernmental level about the present situation and we also are cooperating on (it's part of the same problem) the same sort of disposal in the Arctic, which is being addressed under a program of the International Atomic Energy Authority.

**Gordon McBean:** I just wanted to come back to some points that were made earlier and ask for comment or advice as to what we might try and do in Canada. I noticed when Mr. Kawasaki was making the presentation of his organization chart that one of the members of the committee on science and technology in the Japanese system was the Science Council of Japan. I think one of the issues we have had in Canada in recent times is that although I believe the Science Council may well have been involved in the Japan-Canada science discussions—Pacific 2000 etc.—the Science Council has now disappeared. A number of us are concerned about this, a number of us are also concerned about the follow up on Japan-Canada, the ocean activities and the bridge between countries. I guess I was discouraged to find that the Canadian response was to establish a committee of people who I am sure were all very eminent, but that none of the people who were tasked with the function of developing the ocean plan were recognizable as oceanographers . That made me very surprised and actually angry at the time, when this person from External Affairs came and visited us at UBC and obviously was extremely poorly informed on what was already going on in ocean activities. I guess I would like to ask two questions, one to Japanese colleagues: how do you continue to get government to—or does your government actually pay any attention to—your science council? I think it does from my experience, but if it does how do you continue to have that be the case? And maybe I could ask our Canadian members of the panel, two friends of mine. I am not trying to put you on the spot, but how do we allow in Canada the situation where science councils are dissolved? Working science seems to be disconnected from policy making, and maybe there is a role for the National Academy, whose Chairman is standing at the podium at the moment.

**Yoshio Okawara:** About the science constitution. Recently a Japanese administrative reform council came out with the recommendation that the Japanese government agencies should be reorganized from the current twenty ministries and agencies into six, meaning that with a smaller number of ministries in charge the Japanese Government should more effectively address the tasks to be charged to each individual ministry. This is one indication that the current system in Japan is not very efficient and not a perfect one, but this recommendation itself has not been very favourably received, having received the comment that this is not too practical even though the idea might be a very desirable one. This suggests that even in the field of management or science policy we have some problems involving the various departments and agencies, and certainly we do need to streamline management of science policy in some more concerted way.

**Geoff Holland:** I can say that in terms of interdepartmental input into science policies, we do have, through the Japanese Science and Technology Fund in Canada and the managers of that fund, the people who set some of the international policy. We do have input and we do try and keep the policy advisors in External Affairs aware of what science cooperation is and how it is proceeding. It may not be the best way of doing business but there is a gap I think that was left when the Science Council was abolished that has not yet been filled. Maybe that is something that external affairs can or our new government can address when it gets around to looking at its S&T policy.

**Lawrence Mysak:** Just following on a little bit about science policy I should mention that within the Academy of Science we had a very small science policy committee which was basically struggling with what it should be doing and realizing that this does go beyond just an academy of science. It has now been broadened to a society-wide committee chaired by a very distinguished engineer fellow of this society and also a fellow of the academy of engineering, and includes members of the humanities and social sciences. It is just beginning an active sequence of meetings and hopefully this can provide at least some nongovernment, arms length advice which the government may listen to or otherwise.

**Hugh Morris:** I am the Chairman of the Canadian Global Change Program. I would like to just take a couple of seconds if I may, to make both a comment and bring a question to you again which returns a little bit to Mike Keating's point about communication. I believe that this is an area which we tend to step around very much in our deliberations because it is a little uncomfortable for academics, intellectuals, scientists and so on, but it is critical. Let me share with you the fact Dr. Bornhold and I were invited to attend a conference sponsored by the Social Sciences and Humanities Research Council at Whistler a couple of months ago. The principle attendees were a range of atheists, religious leaders from all the world's religions, and a number of other scholarly individuals. Their symposium title was Population and Consumption. I think it would be fair, if I could generalize, to say that the environment was a key concern of everybody there, as was population demographics and the population explosion, and man's abuse of the planet earth—I could give you a litany of what you would expect.

Secondly, it was equally clear, and I can assure you that I was the only industry representative present, that to them as a representative sampling of intelligent and generally well informed people, science and technology were pretty largely bad, and that included the science and technology associated with the environmental concern movements, which were clearly present here.

So there is obviously a communication gap in existence somewhere. Let me remind you that the Global Change Program of the Royal Society of Canada has included people from the humanities and social sciences from the very beginning. I think it is the only national program anywhere in the world which started out on that basis and as Dr. Mysak can tell you it is has lead to some quite startling and quite interesting discussions which have taken place in our meetings from time to time.

I believe there is real room here for discussion and dialogue between Japan and Canada. When we see numbers presented, for example that the number of researchers for ten thousand people is far higher in Japan, certainly than in our country and most other parts of the world, we have to believe that you are somehow communicating better with your community than perhaps we are. When we hear the complaints which come through in mild cynicism from Kirk Dawson about how he is unable to influence policy makers. I think from a Canadian perspective we are not able to influence the community and it is in the community that the power lies. The politicians will respond to the community. They will not respond to self interest advisors who come from our perspective. So obviously, there is a whole process of this interface, if we live in the information society, which we all talk about, we are not dealing with that part of the information exchange and the transfer of understanding and knowledge.

I would suggest we follow suggestions made earlier, that there is indeed a position here for collaboration by committee, by joint discussion, or other means between our two nations on how do we carry the messages to other parts of our society. When are we affective? When are we ineffective and maybe we can learn from each other.

**John Robinson:** I just actually want to follow up exactly on that comment. Looking at the title of this symposium, *The Future of the Global Environment*, I see and have heard today two completely different interpretations of what that means. There is the question of what is the best understanding of the nature of the biophysical systems that make up the global environment and a whole bunch of issues about science and technology that relate to our understanding of those natural systems. We have a whole science and technology policy in Canada, at least, that more or less takes the view of that's what questions on the future global environment are all about. But we keep hearing bubbling to the surface throughout the day a rather broader sense that the future of the global environment actually involves people other than researchers. I think that this is a fairly crucial aspect of the future of the global environment and I think the time is maybe right for the linkage to be made much more directly than it has been made in the past. There are two aspects of these linkages that I would like to propose.

One is the policy linkage. Despite the fact that here we have two countries doing really world class, leading edge research, we have a general failure in the policy arena in actually turning this into action to resolve the problems that are so adequately, beautifully and colourfully shown through earth observation and other techniques, and about which we are starting to get some understanding by a physical arena. We know that all OECD countries have energy targets and in fact have signed international agreements, utterly in variance with their own internal energy policies. So there is a kind of gap here and it might be nice to think that there should be some connection between the very large amounts of money spent on figuring out what the problem is and the comparatively tiny amounts spent on actually doing something about it. I think that linkage wherein the natural science community say we tell you what's going on but the question of policy is outside our round, that's a problem. And it's a problem increasingly in deficit reduction times because increasingly the bottom line for science policy in Canada is contributing to industrial competitiveness. So if we don't start making that linkage, even the national science community is going to be faced with an increasing problem of getting money for pure research, not just for pure curiosity-driven research, but any kind of research that doesn't show that connection. One way to show that connection is through the policy loop. I think we should start thinking seriously about how that can be done.

The second dimension is that in fact there are a few causes of global change that come from people as well. If we are ever going to come to some understanding of the systems that go beyond these kinds of really simplistic two times $CO_2$ approaches, to thinking about what's happening out there and what the consequences might be, we have to integrate the human systems as causes and in terms of consequences of these changes into the modelling approaches. We see with IGBP an attempt to apparently successfully start linking the physical and the biological models, and we should maybe be thinking the next step. The next step I would submit is linking in the social economic modelling into that loop as well.

If you look at IPCC they are now, in the second assessment report, going to be incorporating economics and other social sciences directly into Working Group III in a fairly major way. But what they are going to find is they don't know very much. IPCC is science assessment. It's not doing the science. We need to do some of that and I think since both Japan and Canada have taken public international positions of leadership on environmental issues on questions like the future of the global environment, it might be really appropriate for a strategic partnership of these two countries to go out ahead of what's going on around most of the planet and make some of these connections. Thank you.

**Michael Keating:** At the risk of imposing on your time, I would like to make one modest suggestion. The focus of the very interesting workshop today has been very much on the technologies and the techniques of science. How do we know what the problems are? I am very concerned that the environmental agenda is driven by the word problem. It is true that it is an underlying issue but we don't somehow turn that around and talk more about the opportunities for change that really exist. Now that we know the problems and that there are a lot of things we can do, we are going to see environmental issues put in a pigeon hole and funding will be cut because politicians don't want only bad news. I would like to suggest that there is a real opportunity for research in how to effectively communicate the opportunities that exist for a successful and sustainable economy, now that we better understand the environmental framework called limitation, if you like, that exists. I would welcome suggestions from people as to success stories in communicating how to work within environmental parameters or limitations because I think we need to build on that if we are going to get anywhere beyond very frustrating discussions about the problems and 'somebody should do something about it'. Thank you.

**John Hollins:** I am from Environment Canada. I am intrigued with this notion of wishing to communicate and I share it, but a couple of weeks ago I was at a meeting, an International Nuclear Congress in Toronto. That is a community which also wants to communicate with decision makers and the public at large. When they say communicate, I am not sure whether Mr. Keating and my friend Mr. Robinson are thinking exactly the same thing, but they might be thinking at least partly in the same way as this nuclear energy community that I was visiting. What they really meant is that they want to tell decision makers and the public at large something. In my observation, communication is a two way street, and if members of a distinguished learning society in Japan, some other country, or my country want to communicate, we better make sure we start by listening. We better make sure that we at least make a serious effort to understand the values that the various parties bring to the communication. There I think processes in human behaviour become very important in the context of collaboration between Japan and Canada on global change issues, not problems. I think our friend's observation just now was very pertinent. I would love to see, despite the substantial cultural differences, how the Japanese people talk to each other, communicate with each other and secure over a period of time the kind of decisions which lead to so many researchers per thousand, or such and such a level of GNP devoted to research in general, or global change research in particular. We would have a few small contributions to offer from the Canadian side, because I submit Mr. Chairman that whatever its defects may be, and there are bound to be some since it was a human endeavour, one of the things which the Canadian Government did well in formulating its Green Plan was to have some deliberate and I submit successful consolidations with interested Canadians who were not necessarily in the professional loop of Green Plan things. So I would welcome ongoing work between Canada and Japan—a serious effort, perhaps in research, to understand dynamics of processes between Japanese people from different walks of life. And quite frankly I would prefer if possible to do that in a wider rather than a bilateral setting. But if a Japanese-Canadian tool is available to us, and obviously it is, this might be a starting point.

# Closing Remarks

*Mr. Hiromori Kawashima*
*President, The Honda Foundation*

Please allow me to make my greetings in Japanese. Dr. Meisel, President of the Royal Society of Canada, Dr. Mysak, President of the Academy of Science, Dr. Morris, Chairman of the Canadian Global Change Program, Dr. Rowe, Executive Director, Institute of Space and Terrestrial Science and distinguished guests and ladies and gentlemen.

I would like to express my appreciation for your participation in today's symposium, *The Future of the Global Environment: The Role of Canadian and Japanese Science and Technology*. Despite the fact that it was limited to only a one day workshop, heated discussions have taken place and this symposium is about to come to an end. This could not have been possible without your enthusiasm and devotion and I would like to thank every single one of you present here for your support. These valuable and fruitful results would not have been possible without Dr. Meisel, President of the Royal Society of Canada, Dr. Brian Bornhold, Director, Canadian Global Change Program, Dr. Joji Iisaka, Canada Centre for Remote Sensing, Mrs. Iisaka and members of the organizing committee who took the initiative to hold this symposium and spent significant amounts of time for its preparation. For their cooperation and enormous contribution, I would like to express my deep appreciation.

Today's theme, global environmental issues, is now an urgent world wide agenda which is crucial to the existence of mankind. It is a threat hidden in the shadow of prosperity which is the result of the development of science and technology. Plants, birds, animals, insects and fish are all children of the earth just as we human beings are. Water lily, the most beautiful flower in the pond, expresses the growth of its own leaves relative to how big the pond is. Like this water lily in a pond, all plants know how to balance the extent of their size. Plants naturally have a sense of balance and have an ability to comprehend the love of human beings. Humankind have been given an enormous benefit and privilege from all living creatures. Therefore we are now into a stage where we realize that all living creatures ought to participate in the philosophy of existence with nature by having that gentle sense of balance.

Here in beautiful Canada today, we were given this opportunity to listen to first class speakers. It made me realize that nature is the greatest teacher. Nature teaches patience, courage, and kindness. Nature also allows us to learn about consolation and love. Dr. Dawson earlier gave a very interesting talk about climate change. As has been mentioned a number of times, it was probably due to El Niño, but this summer Japan suffered terribly from lack of sunlight, excessive amounts of rain and a cool summer. It was probably the worst year for the rice harvest in two hundred years. Japan has always had a firm policy that it will never ever import rice, not even a grain. But this year's poor crop seems to be leading to a reversal of this policy. Indeed a power that is much larger than that of human beings, in other words nature, can change politics.

The Honda Foundation will continue to seek the excellent wisdom of human beings like you for new science and a vital future. For this we will continue to strive. I ask everyone present here from Canada and Japan for their continued support and with my very best wishes I would like to announce the closing of this symposium. Thank you very much.

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